Starlink SL9003Q

Digital Studio Transmitter Link

Doc. 602-12016-01
Revision G

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Using This Manual - Overview

Section 1 System Features and Specifications
A short discussion of the SL9003Q features and specifications.

Section 2 Quick Start
For the experienced user that wants to get the system up and running as soon as possible. Contains typical audio settings, RF parameters, and performance checks.

Section 3 Installation
Detailed system installation information covering:
Primary power requirements (AC/DC)
Bench test details (for initial pretest)
Site installation details (environmental, rack mount and link alignment)

Section 4 Operation
Reference section for front panel controls, LED indicators, LCD screen displays and software functions:
Front panel controls & indicators
Screen Menu Structure – menu tree & navigation techniques
Screen Summary Tables – parameters & detailed functions.

Section 5 Module Configuration
Listings of jumpers, settings and options useful for diagnosis and custom systems:
Module configuration
Troubleshooting guide

Section 6 Customer Service
Information to obtain customer assistance from the factory.

Section 7 System Information
System theory discussion for a better understanding of the SL9003Q:
System Block Diagrams
Module Details and Block Diagrams
Appendices
Additional material for reference and design. These include:
Path Evaluation Information
Audio Considerations
Glossary of Terms
Conversion Chart (microvolts to dBm)
Spectral Emission Masks
Redundant Configurations
Use in Hostile Environments

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1 System Features and Specifications

1.1 System Introduction

The Moseley STARLINK 9000 is the first all-digital, open-architecture, modular system for CD-quality audio transmission. The versatility and power of the STARLINK 9000 comes from a complete range of “plug and play” personality modules.

The SL9003Q Digital Studio-Transmitter Link (DSTL) provides a transmitter/receiver pair that conveys high quality digital audio, either discrete or composite audio program information, across a microwave radio path. Typically, program material is transmitted from a studio site to a remote transmitter site, to a repeater site, or in an intercity relay application.

Utilizing spectrally efficient digital Quadrature Amplitude Modulation (QAM) technology, the SL9003Q delivers either four discrete 16-bit linear audio channels with two data channels or a 16-bit linear stereo composite channel with up to three data channels over standard FCC Part 74 (950 MHz) STL frequency allocations.

As a discrete STL, the AES/EBU digital audio I/O, combined with a built-in variable sample rate converter, provide seamless connection to the all-digital air chain without compression. The system has provisions for two asynchronous auxiliary data channels (up to 38,400 baud) that are used for communication in remote control applications. Plug-in MPEG audio modules and a digital multiplex allow for additional program, voice, FSK, async and sync data channels.

As a composite STL, the stereo I/O allows transparent analog-composite transmission directly from the audio processor/stereo generator at the studio site to the FM exciter at the transmitter site. The analog composite signal is digitized and transmitted digitally providing both error-free RF performance and significant sonic benefit; near flawless channel response that exceeds most generation equipment, ultimate stereo separation, dynamic range, and virtually no low-end frequency overshoot. The digital composite STL operates similar to a traditional analog composite STL, such as the Moseley PCL-6000 and PCL-606C series, and can directly replacement an existing analog composite STL (with special considerations for mixed analog-STL/digital-STL hot-standby configurations – see appendix).

The high spectral efficiency of the SL9003Q is achieved by user-selectable 16, 32, 64 or 128 QAM. Powerful Reed-Solomon error correction with interleaving, coupled with 20-tap adaptive equalization, provide unsurpassed error-free signal robustness in hostile RF environments for which there is no comparable benefit in analog transmission.

1.2 System Features

In addition to establishing a new industry standard for studio-transmitter link performance, the SL9003Q incorporates many new and innovative features, including:

- Linear 16 bit digital audio performance.
- Higher system gain, 26 dB more than analog composite STL.
- Degradation-free multiple hops.
- Configurable for up to 4 linear audio program channels per STL system.
- No crosstalk between channels.
- No background chatter from co-channel or adjacent-channel interference.
- Built-in AES/EBU digital audio interface.
- Operation through fractional T1 networks.
- Composite response to 0.1 Hz for improved processing loudness.
- Highest stereo separation and SNR achievable in a composite STL.
- Built-in data channels alleviate the need for FM subcarrier data channels.
- Extensive LCD screen status monitoring.
- Peak-reading LED bar graph display for all audio channels.
- Adjustable bit error rate threshold indication for monitoring transmission quality.
- Important status functions implemented with bi-color LED indicators.
- Modular construction that provides excellent shielding, high reliability, easy servicing, and upgrade capability
- Selectable RF spectral efficiency.
- Sample rate converter (SRC) for digital audio operation from 30 to 50 kHz.

1.3 Specifications

1.3.1. System Specifications - Discrete

Audio Capacity **(Typical Configurations)**	4 linear (32 or 44.1 kHz sample rate) + 2 data channels; 2 linear (44.1 kHz sample rate) + LAN (500 kbps) with 6-port MUX 2 linear (44.1 kHz sample rate) + 1 data channel
Frequency Range(s)	160-240 MHz 330-512 MHz 800-960 MHz 1340-1520 MHz 1650-1700 MHz (Fully Synthesized, front-panel programmable, no adjustments)
Frequency Step Size	25 kHz
Occupied Bandwidth	200/250/300/500 kHz Note: Rate & QAM mode dependent, see Table 1-1 for details.
RF Spectral Efficiency	See Appendix
Threshold Performance	See Table 1-1 below for details.
Audio Frequency Response vs. Sample Rate:	
32 kHz:	0.5 Hz-15 kHz; -3 dB bandwidth, +/- 0.2 dB flatness
44.1 kHz:	0.5 Hz-20 kHz; -3 dB bandwidth, +/- 0.2 dB flatness
48 kHz:	0.5 Hz-22.5 kHz; -3 dB bandwidth, +/- 0.2 dB flatness
Audio Distortion	<0.01% <0.01% at 1 kHz (compressed)
Audio Dynamic Range	92 dB Digital (AES/EBU) IN/OUT 83 dB Analog IN/OUT
Audio Crosstalk	< -80 dB
Audio Data Coding Method	Linear ISO/MPEG (Layer II)
Audio Sample Rate	Selectable 32, 44.1, 48 kHz built-in rate converter
Audio Coding Time Delay	Linear: 0 ms ISO/MPEG: 22 ms
Channel Coding Time Delay **(Add to Audio Coding Delay above)**	Depends on Interleave Factor - QAM Modem Configuration: 1 - 2.6 mS 2 - 3.7 mS 3 - 5.0 mS (typical) 4 - 6.0 mS 6 - 8.0 mS 12 - 14.0 mS

Bit Error Immunity	>1X10E-4 for no subjective loss in audio quality
Async Data Channels	One for each audio pair
Aggregate Transmission Rates	Depends on number of audio channels
Diagnostics	FWD Power, REV Power, TX Lock, Radiate, RSL, BER, RX Lock
Status Indicators	Full Duplex: Fault, Alarm, Loopback, TX, TXD, RX, RXD, NMS/CPU. Transmitter: Fault, Alarm, VSWR, Radiate, Standby, AFC Lock, Modulator Lock, NMS/CPU. Receiver: Fault, Alarm, Attenuator, Signal, BER, AFC Lock, Demodulator Lock, NMS/CPU.
Fault Detection and Logging	REV Power, PA Current, LO Level, Exciter Level, RSL, BER, Synth Level, Modem Level
Alarm Detection and Logging	FWD Power, AFC Lock , PA Temp, MBAUD, DBAUD, DFEC
Temperature Range	Specification Performance: 0 to 50º C Operational: -20 to 60º C

1.3.2. System Specifications - Composite

Audio Capacity	Composite Stereo linear (128 kHz sample rate) + 1 async. data channel; Composite Stereo linear (145 kHz sample rate) + 1 async. data channel + 2 configurable sync/async data channels
Frequency Range	160-240 MHz 330-512 MHz 800-960 MHz 1340-1520 MHz 1650-1700 MHz (Fully Synthesized, front-panel programmable, no adjustments)
Frequency Step Size	25 kHz
Occupied Bandwidth	See Table 1-1 below for details.
RF Spectral Efficiency	See Appendix
Threshold Performance	See Table 1-1 below for details.
Composite Frequency Response vs. Sample Rate:	
128 kHz:	0.1 Hz – 60 kHz; -3 dB bandwidth 0.2 Hz – 53 kHz; +/- 0.02 dB flatness
145 kHz:	0.1 Hz – 68 kHz; -3 dB bandwidth 0.2 Hz – 60 kHz; +/- 0.02 dB flatness

Audio Distortion	0.035% or less, 50 Hz to 15 kHz (de-emphasized, 20 Hz – 15 kHz bandwidth, referenced to 100% modulation, unweighted).
Stereo Separation	> 65 dB, 50 Hz to 15 kHz , typically 70 dB or better (referenced to 100% modulation = 3.5Vp-p) > 60 dB, 50 Hz to 15 kHz for Matched Digital Composite Links in Hot-Standby configuration
Signal-to-Noise Ratio	> 82 dB, typically better than 85 dB (75µs De-emphasized, 100% modulation, 50 Hz to 15 kHz)
Nonlinear Crosstalk	> -80 dB, main channel to sub-channel or sub-channel to main channel (referenced to 100% modulation).
Encoding Method	Linear, 16 bit
Composite Coding Time Delay	0 ms
Channel Coding Time Delay **(Add to Audio Coding Delay above)**	Interleave Factor - QAM Modem Configuration: 1 - 2.6 mS 2 - 3.7 mS 3 - 5.0 mS (typical) 4 - 6.0 mS 6 - 8.0 mS 12 - 14.0 mS
Bit Error Immunity	>1x10e-4 for no subjective loss in audio quality
Async Data Channels	One 300 baud standard, up to 9600 baud, and choice of Asynchronous: 300-38400 bps; Synchronous: 16, 24, 32, 64 kbps;
Aggregate Transmission Rates	2048 kbps/2432 kbps depending on configuration
Diagnostics	FWD Power, REV Power, TX Lock, Radiate, RSL, BER, RX Lock
Status Indicators	Full Duplex: Fault, Alarm, Loopback, TX, TXD, RX, RXD, NMS/CPU. Transmitter: Fault, Alarm, VSWR, Radiate, Standby, AFC Lock, Modulator Lock, NMS/CPU. Receiver: Fault, Alarm, Attenuator, Signal, BER, AFC Lock, Demodulator Lock, NMS/CPU.
Fault Detection and Logging	REV Power, PA Current, LO Level, Exciter Level, RSL, BER, Synth Level, Modem Level
Alarm Detection and Logging	FWD Power, AFC Lock , PA Temp, MBAUD, DBAUD, DFEC
Temperature Range	Specification Performance: 0 to 50º C Operational: -20 to 60º C

Table A- 1
Bit Rate, Threshold and Bandwidth for SL9003Q Equipment Variations

Application	Bit Rate (kbps)	10E-4 Threshold (dBm)			Bandwidth ** (kHz)		
		16 QAM	32 QAM	64 QAM	16 QAM	32 QAM	64 QAM
2-Channel Linear Audio 32 kHz Sample & 1 data channel	1024	-93	-91	-89	300	250	200
2-Channel Linear 48 kHz Sample & 1 Data Channel	1536	-91.5	-89.5	-87.5	450	375	300
4-Channel Linear 32 kHz Sample & 2 Data Channels **Composite Stereo Linear Channel 128 kHz Sample & 1 async. data channel**	2048	-90	-88	-86	600	500	400
Composite Stereo Linear Channel 145 kHz Sample & 1 async./2 sync data chnl	2432	-	-	-85	-	-	500

** Measured using FCC 50/80 dB Digital Mask.

1.3.3. Transmitter Specifications

Frequency Range	160-240 MHz 330-512 MHz 800-960 MHz 1340-1520 MHz 1650-1700 MHz (Fully Synthesized, front-panel programmable, no adjustments)
RF Power Output	1 Watt @ 16, 32, 64, 128 QAM, 160-240/330-512/800-960 MHz 0.5 Watt @ 16, 32, 64, 128 QAM, 1340-1520/1650-1700 MHz
RF Output Connector	Type N (female), 50 ohms
Frequency Stability	0.00001 % (0.1 PPM), 0 – 50º C

Spurious and Harmonic Emission	< -60 dBc
Type of Modulation	User Selectable: 16, 32, 64, 128 QAM
FCC Emission Type Designation	200KD7W 250KD7W 300KD7W 500KD7W
FCC Identifier	CSU9WKSL9003Q74
Power Source	AC: Universal AC, 90-260 VAC, 47-63 Hz DC: +/- 12 VDC +/- 24 VDC +/- 48 VDC Isolated chassis ground
Power Consumption	70 Watts
Dimensions	17” W x 14” D x 5.2” H (3RU) [43.2 cm x 35.6 cm x 13.2 cm]
Weight	24 lbs. (52.8 kg)

1.3.4. Receiver Specifications

Type of Receiver	Dual conversion superheterodyne 1st IF = 70 MHz, 2nd IF = 6.4 MHz
Frequency Range	160-240 MHz 330-512 MHz 800-960 MHz 1340-1520 MHz 1650-1700 MHz (Fully Synthesized, front-panel programmable, no adjustments)
Receiver Dynamic Range	–35 dBm to –95 dBm
Adjacent Channel Rejection	10 dB with similar Digital SL9003Q system or with DSP 6000/PCL 6000 link.
Image Rejection	70 dB min
Antenna Connector	Type N (female), 50 ohms
Type of Demodulation	Coherent 16, 32, 64, 128 QAM
Error Correction	Reed-Solomon, t = 8
Equalizer	20 tap adaptive
Frequency Stability	0.00001 % (0.1 PPM), 0 – 50º C
BER Threshold Mute Adjust	-95 dBm
Receiver Sensitivity	See Table 1-1 above.
Power Source	Receiver power consumption: 65 Watts
Dimensions	17” W x 14” D x 5.2” H (3RU) [43.2 cm x 35.6 cm x 13.2 cm]
Weight	17 lbs (37.4 kg)

1.3.5. Audio Encoder Specifications

Sample Rate	32/44.1/48 kHz selectable, built-in rate converter
Analog Audio Input	XLR female, electronically balanced, 600/10k ohm selectable, CMRR > 60 dB
Analog Audio Level	-10 dBu to +18 dBu, rear panel accessible
Digital Audio Input	AES/EBU: Transformer balanced, 110 ohm input impedance SPDIF: Unbalanced, 75 ohm input impedance
Data Input	9-pin D male RS-232 levels Async. 300 to 38400 bps selectable
ISO/MPEG Modes	Mono, dual channel, joint stereo, stereo (ISO/IEC 111172-3 Layer II) Sample Rate: 32/44.1/48 kHz selectable Output Rate: 32/48/56/64/80/96/112/128/160/192/224/256/320/384 kHz selectable

1.3.6. Audio Decoder Specifications

Sample Rate	32/44.1/48 kHz selectable, built-in rate converter
Analog Audio Output	XLR male, electronically balanced, low Z/600 ohm selectable
Analog Audio Level	-10 dBu to +18 dBu, rear panel accessible
Digital Audio Output	AES/EBU: Transformer balanced, 110 ohm input impedance SPDIF: Unbalanced, 75 ohm input impedance
Data Output	9-pin D male RS-232 levels Async. 300 to 38400 bps selectable
ISO/MPEG Modes	Mono, dual channel, joint stereo, stereo (ISO/IEC 111172-3 Layer II) Sample Rate: 32/44.1/48 kHz selectable Input Rate: 32/48/56/64/80/96/112/128/160/192/224/256/320/384 kHz selectable

1.3.7. Composite Specifications

Input Level	3.5 Vp-p for 100% modulation; (1.8 - 4.8 Vp-p rear-panel adjustable)
Input Type	BNC female, unbalanced, 100kohms
Output Level	3.5 Vp-p for 100% modulation; (1.8 - 4.8 Vp-p rear-panel adjustable)
Output Type	BNC female, unbalanced, Low-Z (<5 ohms)
Output Load	75 ohms or greater, maximum load capacitance 0.047 microfarads. Maximum recommended cable length 100ft RG-58A/U
Data Interface (standard)	9-pin D male, RS-232, 300 baud, 8 bit, odd parity (default)
Data Interface (optional)	2 additional channels available with choice of: Voice; Low Speed Async Data (RS-232); High Speed Sync Data (V.35, RS-449); 15-pin D female, IBOC transport Rates: Async data, 300-38400 bps selectable Sync data up to 64 kbps Voice 16, 24, 32, 64 kbps
Trunk	15-pin D female, Synchronous V.35, RS-449, EIA-530 Rates: 2048 Mbps @ 32 QAM 2432 Mbps @ 64 QAM

1.3.8. Intelligent Multiplexer Specifications

Capacity	6 local Ports
Aggregate Rates	Up to 2.048 Mbps
Resolution	8000 bps, 768-2048 kbps; 4000 bps, 384-768 kbps; 2000 bps, 192-384 kbps, 1000 bps, 96-192 kbps; 500 bps, 48-96 kbps; 250 bps, 24-48 kbps
Clocks	Internal, Derived, External Port
Local Port Interfaces	Choice of: UDP Stream/Ethernet Voice; Low Speed Async Data (RS-232), High Speed Sync Data (V.35, RS-449)
Data Rates	Low Speed 300-38400 bps; Voice 16, 24, 32, 64 kbps; High Speed to 2040 kbps
Trunk	V.35 or RS-449

1.4 Regulatory Notices

FCC Part 15 Notice

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Any external data or audio connection to this equipment must use shielded cables.

FCC Part 74 Equipment Authorization

The SL9003Q Transmitter has been granted Equipment Authorization under Part 74 of the FCC Rules and Regulations.

Equipment Class:	***Broadcast Transmitter Base Station***
Frequency Range:	***944-952 MHz***
Emission Bandwidth:	***200 – 500 kHz***
FCC Identifier:	***CSU9WKSL9003Q74***

2 Quick Start

2.1 Unpacking

The following is a list of all included items.

Description		Qty
SL9003Q Transmitter (3RU)	(STL Link)	1
SL9003Q Receiver (3RU)		1
SL9003Q Transceiver (3RU)	(Repeater)	1
Rack Ears	(w/hardware)	4
Power Cord	(IEC connector)	2
Manual - CDROM	(call for printed manual)	1
Test Data Sheet	(customer documentation)	2

Be sure to retain the original boxes and packing material in case of return shipping. Inspect all items for damage and/or loose parts. Contact the shipping company immediately if anything appears damaged. If any of the listed parts are missing, call the distributor or Moseley immediately to resolve the problem.

2.2 Notices

CAUTION

DO NOT OPERATE UNITS WITHOUT AN ANTENNA, ATTENUATOR, OR LOAD CONNECTED TO THE ANTENNA PORT. DAMAGE MAY OCCUR TO THE TRANSMITTER DUE TO EXCESSIVE REFLECTED RF ENERGY.

ALWAYS ATTENUATE THE SIGNAL INTO THE RECEIVER ANTENNA PORT TO LESS THAN –37 dBm (3000 uV). THIS WILL PREVENT OVERLOAD AND POSSIBLE DAMAGE TO THE RECEIVER MODULE.

DO NOT ATTEMPT TO ADJUST TRANSMITTER POWER. THIS WILL CAUSE THE LINK TO FAIL TO OPERATE.

AVOID EXCESSIVE PRESSURE ON THE AUDIO ADJUSTMENT POTENTIOMETERS LOCATED ON THE BACK PANELS OF THE AUDIO ENCODER/DECODER MODULES.

WARNING

HIGH VOLTAGE IS PRESENT INSIDE THE POWER SUPPLY MODULE WHEN THE UNIT IS PLUGGED IN. REMOVAL OF THE POWER SUPPLY CAGE WILL EXPOSE THIS POTENTIAL TO SERVICE PERSONNEL.

TO PREVENT ELECTRICAL SHOCK, UNPLUG THE POWER CABLE BEFORE SERVICING.

UNIT SHOULD BE SERVICED BY QUALIFIED PERSONNEL ONLY.

PRE-INSTALLATION NOTES

- *Always pre-test the system on the bench in its intended configuration prior to installation at a remote site.*
- *Avoid cable interconnection length in excess of 1 meter in strong RF environments.*
- *Do not allow the audio level to light the red "clip" LED on the front panel bar graph, as this causes severe distortion (digital audio overload).*
- *We highly recommend installation of lightning protectors to prevent line surges from damaging expensive components.*

2.3 Rack Mount

The SL9003Q is normally rack-mounted in a standard 19” cabinet. Leave space clear above (or below) the unit for proper air ventilation of the card cage. The rack ears are typically mounted as shown in Figure 2-1. Other mounting methods are possible, as outlined in Section 3, Installation.

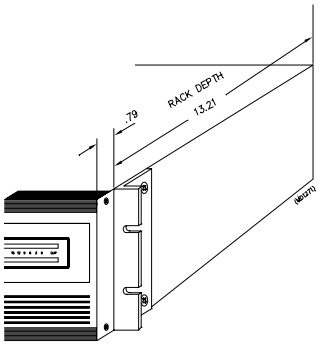


Figure 2-1 SL9003Q Typical Rack Mount Bracket Installation

2.4 Typical System Configurations

System	Audio Channel	Auxiliary Data Channel
Digital STL TX /RX Pair	2-Channel Linear Audio	1 data channel RS232
Digital STL TX /RX Pair	4-Channel Linear Audio	2 data channels RS232
Digital STL TX /RX Pair	2-Channel Linear Audio w/LAN	1 UDP Stream data channel, 544 kbps (6-Port Mux)
Repeater Full Duplex	No Audio Channels	No Data Channels
Repeater Full Duplex	Up to 4 Audio Channels Drop Only (using Audio Decoder)	1 data channel drop available

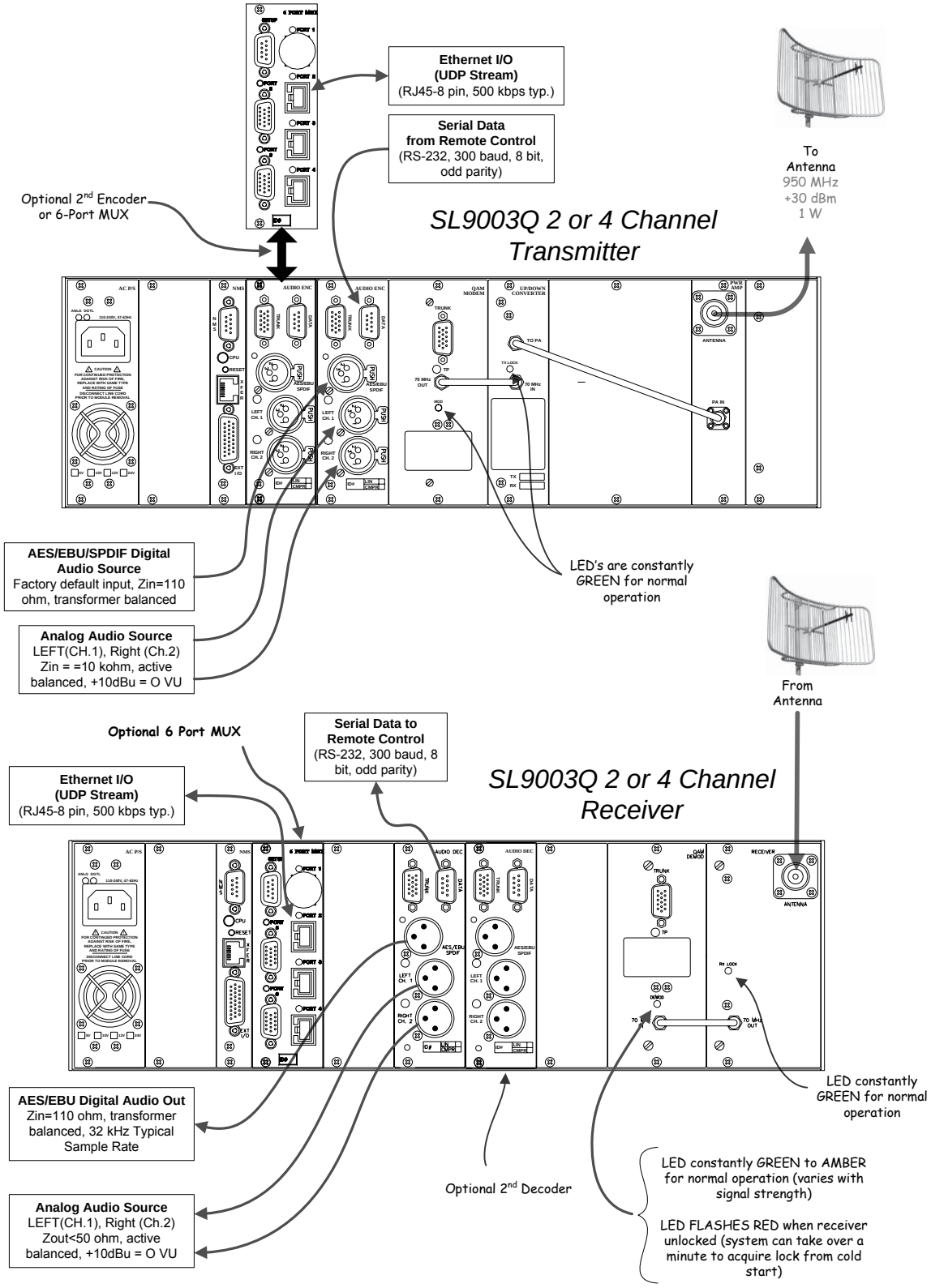

Ethernet I/O
(UDP Stream)
(RJ45-8 pin, 500 kbps typ.)
Serial Data
from Remote Control
(RS-232, 300 baud, 8 bit, odd parity)
To
Antenna
950 MHz
+30 dBm
1 W
Optional 2nd Encoder
or 6-Port MUX
SL9003Q 2 or 4 Channel
Transmitter
AES/EBU/SPDIF Digital
Audio Source
Factory default input, Zin=110 ohm, transformer balanced
Analog Audio Source
LEFT(CH.1), Right (Ch.2)
Zin = =10 kohm, active balanced, +10dBu = O VU
LED's are constantly GREEN for normal operation
From
Antenna
Optional 6 Port MUX
Serial Data to
Remote Control
(RS-232, 300 baud, 8 bit, odd parity)
Ethernet I/O
(UDP Stream)
(RJ45-8 pin, 500 kbps typ.)
SL9003Q 2 or 4 Channel
Receiver
AES/EBU Digital Audio Out
Zin=110 ohm, transformer balanced, 32 kHz Typical Sample Rate
Analog Audio Source
LEFT(CH.1), Right (Ch.2)
Zout<50 ohm, active balanced, +10dBu = O VU
Optional 2nd Decoder
LED constantly GREEN for normal operation
LED constantly GREEN to AMBER for normal operation (varies with signal strength)
LED FLASHES RED when receiver unlocked (system can take over a minute to acquire lock from cold start)

Figure 2-2 SL9003Q 2 or 4 Channel Digital STL Setup

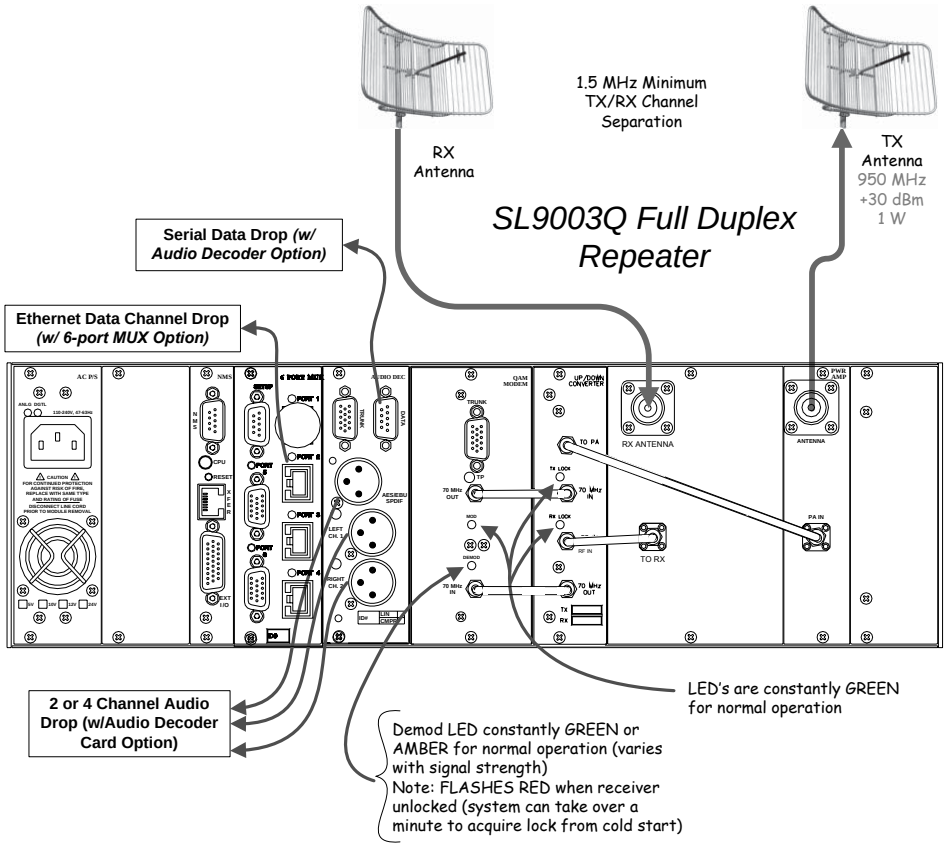


Figure 2-3 SL9003Q Repeater Setup

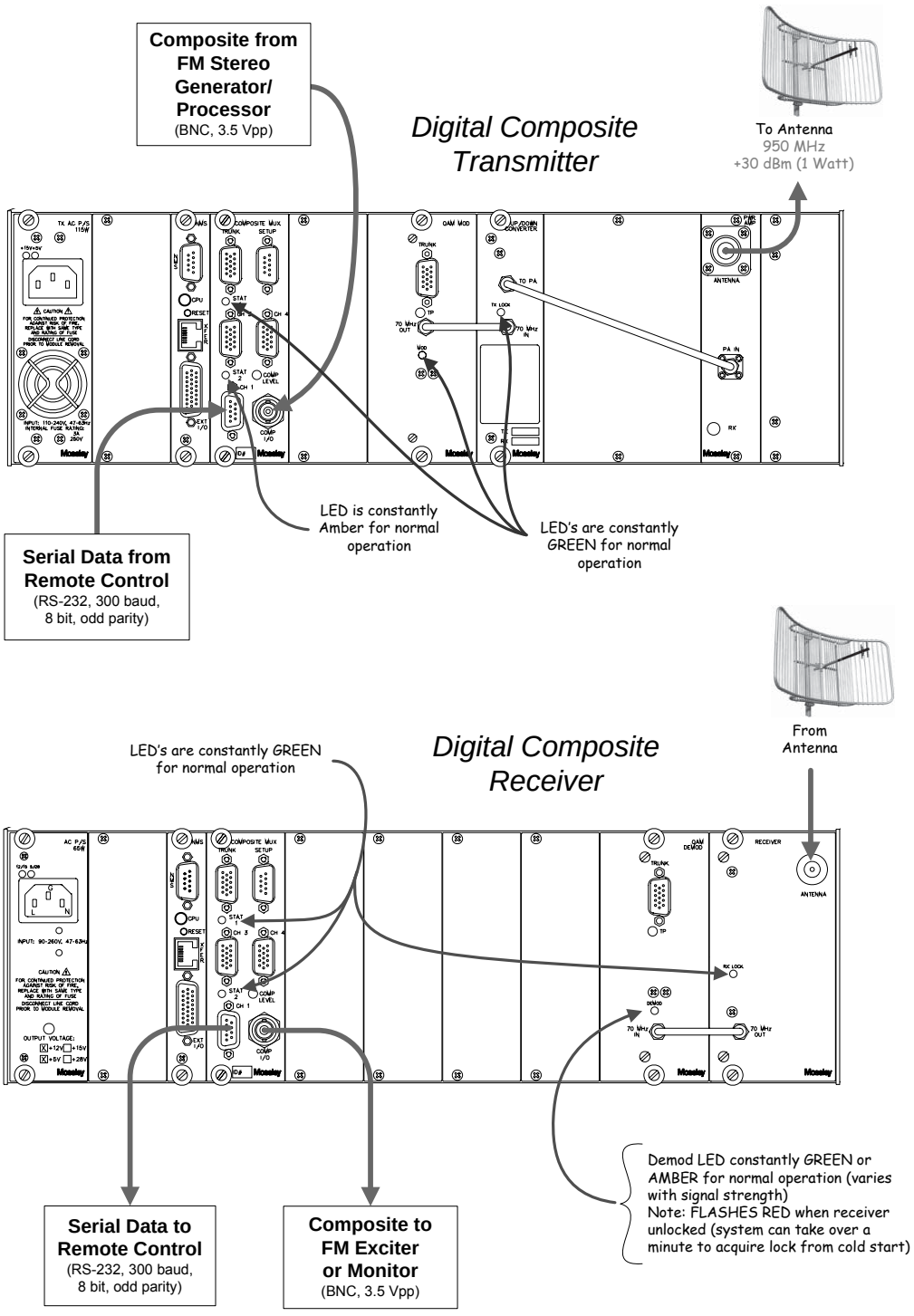
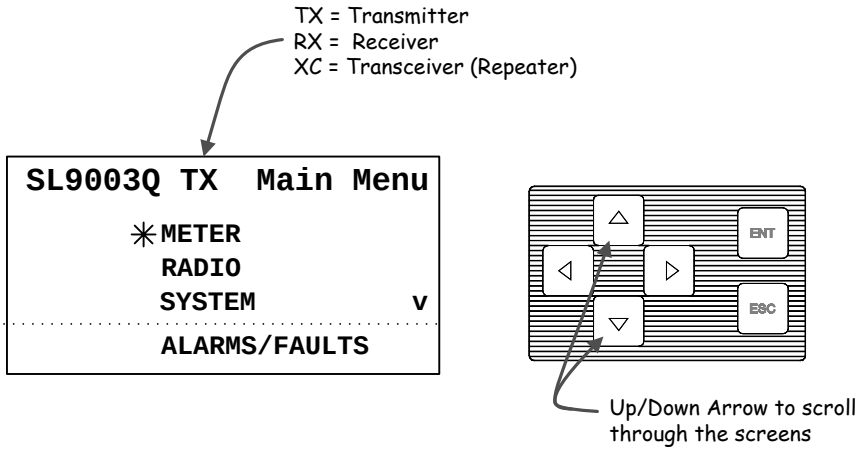

Composite from FM Stereo Generator/ Processor
(BNC, 3.5 Vpp)
Digital Composite Transmitter
To Antenna
950 MHz
+30 dBm (1 Watt)
LED is constantly Amber for normal operation
LED's are constantly GREEN for normal operation
Serial Data from Remote Control
(RS-232, 300 baud, 8 bit, odd parity)
From Antenna
LED's are constantly GREEN for normal operation
Digital Composite Receiver
Demod LED constantly GREEN or AMBER for normal operation (varies with signal strength)
Note: FLASHES RED when receiver unlocked (system can take over a minute to acquire lock from cold start)
Serial Data to Remote Control
(RS-232, 300 baud, 8 bit, odd parity)
Composite to FM Exciter or Monitor
(BNC, 3.5 Vpp)

Figure 2-4 SL9003Q Digital Composite Setup

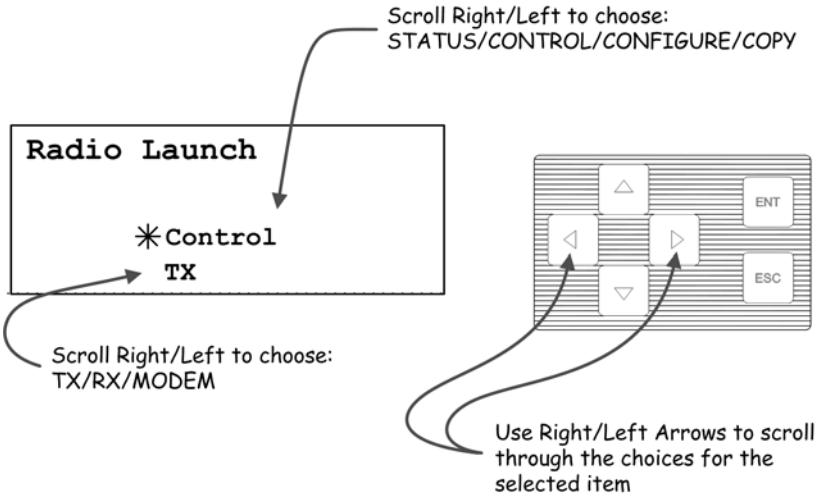
2.5 Transmitter Power-Up Setting

The LCD screen (“RADIO TX CONTROL”) selects the power-up state and controls the radiate function of the TX unit.

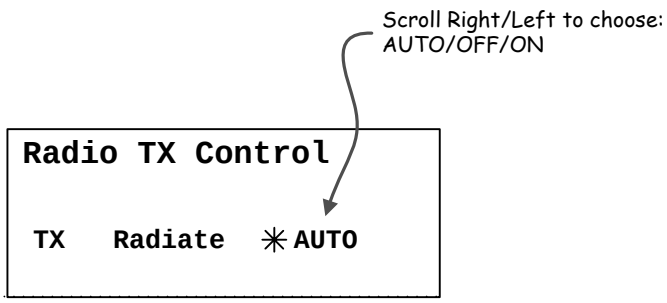
The unit powers up to the MAIN MENU:



- Scroll Down to RADIO, press ENTER.
- Configure the launch screen for "CONTROL TX".

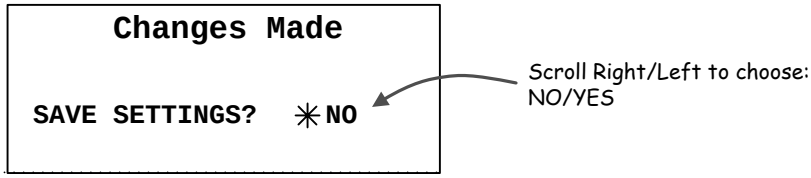


- Verify the AUTO setting (default setting, as shipped).



RADIO TX CONTROL SETTING	Functional Description
AUTO	Transmitter will remain in radiate at full power unless the VSWR of the load causes a high reverse power indication at the RFA. If this is the case , the red VSWR LED will light and the transmitter will cease radiating. Additionally, the transmitter will protect its RFA by "folding back" the ALC (Automatic Level Control) under a bad load VSWR condition.
ON	Transmitter will remain in radiate at full power under all antenna port conditions (not recommended).
OFF	Transmitter in standby mode.

- Press ESC to accept the setting
- If change was made from original power-up setting, you will see the following screen:



- Choose YES, press ENTER to accept.

2.6 Default Settings and Parameters

Listed below are the typical default module settings and parameters. This gives the experienced user a brief rundown of the pertinent information required for system setup. These settings may be accessed through board jumpers or software switches. See Section 5, Module Configuration, of this manual for a detailed account of the various module settings and parameters.

2.6.1. Audio

Table 2-1 Encoder/Decoder Typical Settings

Audio Source Input Switching	Digital Audio = Primary, Analog Audio = Secondary (Automatic switch from AES to Analog Input when AES signal is not present)	
Analog Audio Connectors	XLR female (input)	XLR male (output)
Impedance	Active balanced, Zin = 10 kohm	Active balanced, Zout < 50 ohms
Analog Audio Line Levels	+10 dBu = 0 VU Note: 0 dBu = 0.7746 VRMS (1 mW @ Z=600 ohms)	
Digital Audio I/O	AES/EBU: Transformer balanced, 110 ohm impedance 30-50 kHz input sample rate	
Data Coding Method	Linear (16 bit)	ISO/MPEG (Layer II)
Mode	n/a	Stereo (ISO/IEC 111172-3 Layer II)
Sample Rate	n/a	44.1 kHz
Output Rate	n/a	256/384 kbps

2.6.1.1. Identifying Audio Connections (4-Channel Discrete)

In a 4 channel system, there are two physically identical encoders in the transmitter unit and two corresponding decoder modules in the receiver unit (see Fig. 2-2). The modules are identified with an ID # on the rear panel (ENC1, ENC2, DEC1, DEC2). The audio configuration of the module (Linear/Compressed/Data Rate) can be checked on the Test Data Sheet supplied with the units.

2.6.2. Composite

The composite channel is located on the Composite MUX (4-Port) module (see Fig. 2-4).

Table 2-2 Composite MUX (4-Port) Typical Settings

Input Level	3.5 Vp-p for 100% modulation
Input Type	BNC female, unbalanced, 100kohms
Output Level	3.5 Vp-p for 100% modulation
Output Type	BNC female, unbalanced, Low-Z (<5 ohms)
Output Load	75 ohms or greater, maximum load capacitance 0.047 µF. Maximum recommended cable length 100ft RG-58A/U

2.6.3. Data Channels

2.6.3.1. Data Channels on the Encoder/Decoder Module

The normal serial data channels are located at the Encoder and Decoder (labeled "DATA"). For 4 channel systems, ENC1 contains Data Channel 1 and ENC2 contains Data Channel 2 (see Fig.2-2). Dip-switches located at the on Encoder/Decoder modules configure the data channel rates and bit length.

Data Channel - Encoder/Decoder Module	9-pin D male, RS-232 levels, Asynchronous 1200 baud, 8 bits, 1 start & 1-2 stop bits.

2.6.3.2. Data Channels on the Composite MUX (4-Port) module

The Composite MUX data channel is identified by "Ch. 1" on the module (see Fig.2-4). Jumpers on the Composite modules configure proper null-modem operation (see Section 5, Module Configuration, for changing the data channel configuration).

Data Channel - Composite Mux	9-pin D male, RS-232, Set for: 300 baud, 8 bit, odd parity (default) -OR- 1200 baud, no parity (optional)

2.6.3.3. Data Channels on the 6-Port MUX module

The 6-Port MUX is normally used in a Starlink STL system to provide an Ethernet IP data link. The default port is labeled "Port 2".

Data Channel: 6-Port Mux	Ethernet IP (UDP Stream), RJ45-8pin, 544 kbps typ.

2.6.4. RF Module Parameters

The RF module parameters are optimized for the shipping configuration of the unit and there are no user adjustments available. The following parameters are given for reference only. The test data sheet and LCD screens will list the unit's RF telemetry values and will be specific to your unit.

Frequency (MHz)	Power Output Average (Watts)	PA Current (Amps)
160-240	1.0	1.5
300-512	1.0	1.5
800-960	1.0	1.5
1340 - 1520	0.5	1.5
1650-1700	0.5	1.5

2.6.5. QAM Modulator/Demodulator

The QAM Modulator/Demodulator module parameters are optimized for the shipping configuration of the unit and there are no user adjustments available. The following parameters are given for reference only. The test data sheet and LCD screens will list the unit's configuration and telemetry values and will be specific to your unit.

Modulation Type	16, 32, 64, 128 QAM (depends on channel configuration)
IF Frequency	70 MHz

2.7 Performance

After the link is installed, certain performance parameters may be interrogated through the front panel for verification. Section 4, Operations, contains an LCD Menu Flow Diagram and other useful information to assist in navigating to the appropriate screen.

2.7.1. Transmitter Performance Check

Use the RADIO TX STATUS screens to check the SL9003Q Transmitter performance parameters. Fig. 2-5 outlines the navigation to the LCD Screens and gives typical readings. Be sure to check the Test Data Sheet for the actual factory readings from your particular unit.

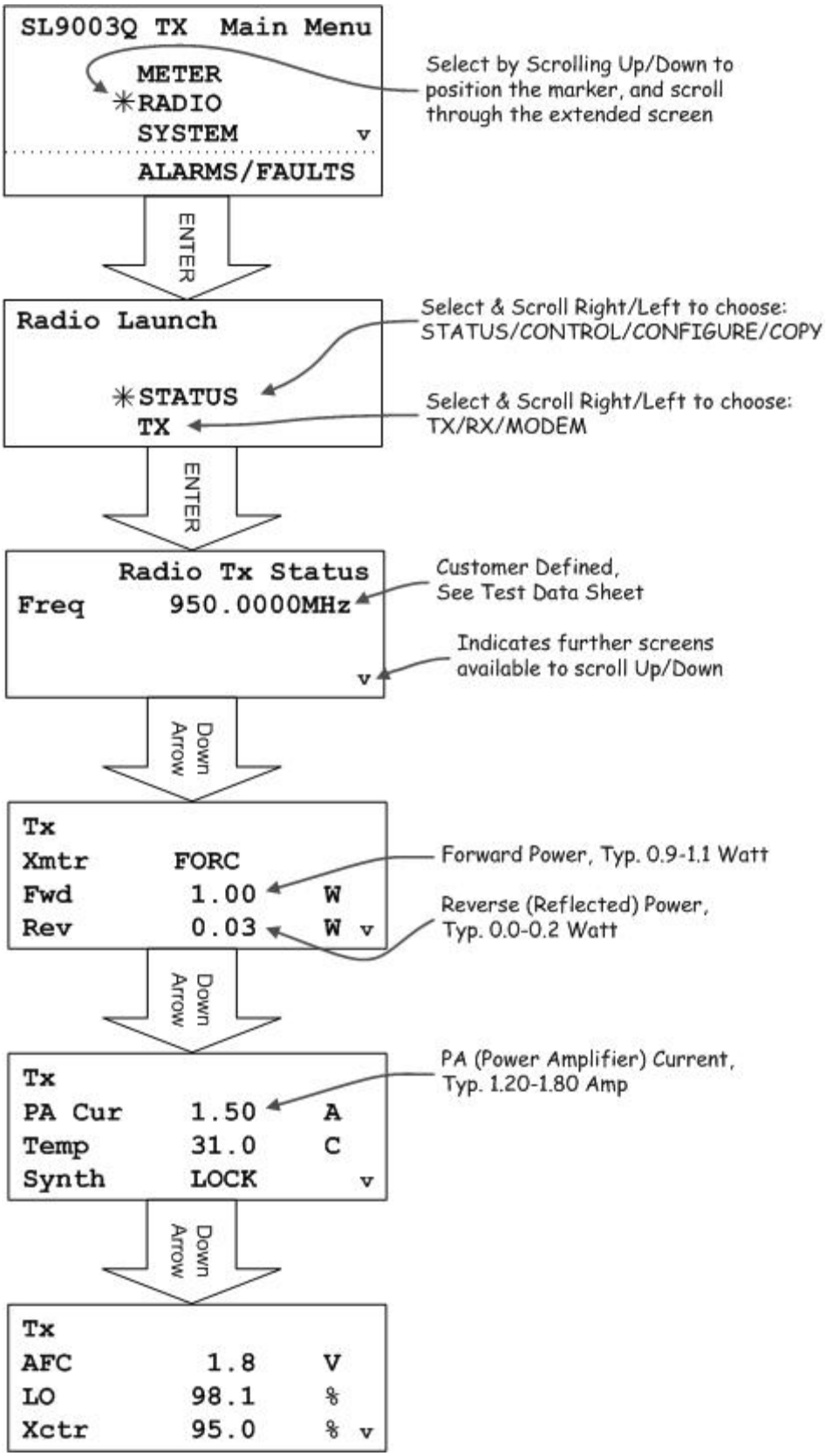


Figure 2-5 Radio TX Status Performance Check

Receiver Performance Check

Use the RADIO MODEM STATUS screens to check the SL9003Q Receiver performance parameters. Fig. 2-6 outlines the navigation to the LCD Screens and gives typical readings. Be sure to check the Test Data Sheet for the actual factory readings from your particular unit.

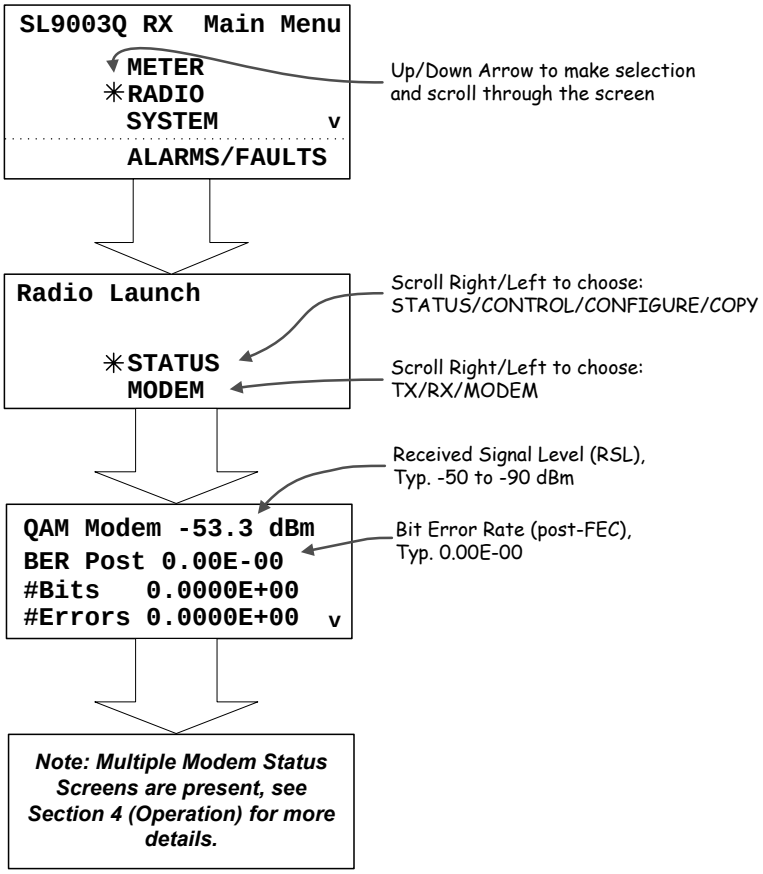

SL9003Q RX Main Menu
METER
RADIO
SYSTEM v
ALARMS/FAULTS
Up/Down Arrow to make selection and scroll through the screen
Radio Launch
STATUS
MODEM
Scroll Right/Left to choose: STATUS/CONTROL/CONFIGURE/COPY
Scroll Right/Left to choose: TX/RX/MODEM
Received Signal Level (RSL), Typ. -50 to -90 dBm
QAM Modem -53.3 dBm
BER Post 0.00E-00
#Bits 0.0000E+00
#Errors 0.0000E+00 v
Bit Error Rate (post-FEC), Typ. 0.00E-00
Note: Multiple Modem Status Screens are present, see Section 4 (Operation) for more details.

Figure 2-6 RX Modem Status Performance Check

2.8 For More Detailed Information...

This “Quick Start” section was designed to give the experienced user enough information to get the studio-transmitter link up and running. Less experienced users may benefit by reading the manual all the way through prior to installation.

If problems still exist for your application, do not hesitate to call Moseley Technical Services for assistance.

3 Installation

3.1 Rear Panel Connections

3.1.1. Power Supply Slot

The leftmost slot in the SL9003Q card cage (as viewed from the rear of the unit) is designated as the “PRIMARY A” power supply. This slot always contains a power supply.

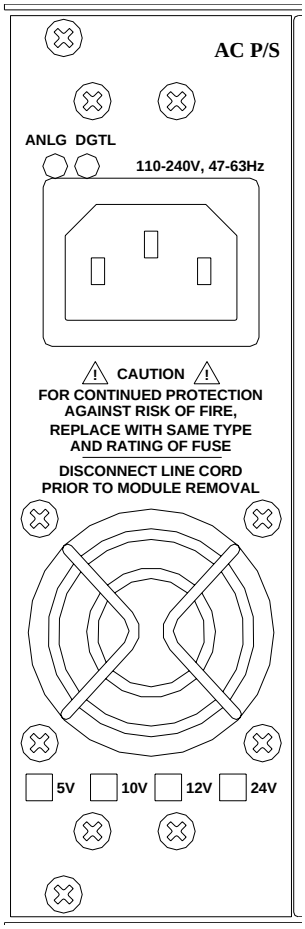
The next slot to the right is designated as “SECONDARY B”. This slot will be occupied only if a high-power amplifier option is installed, or a redundant power supply option is installed. The SL9003Q TX utilizes these slots to separate the PA supply lines for the HPA option.

NOTE:

The front panel LCD screen displays the system supply voltages and the nomenclature follows the physical location of the power supply modules.

3.1.2. AC Power Supply

The SL9003Q TX and RX both use a high reliability, universal input switching power supply capable. The power supply module is removable from the unit and a cage protects service personnel from high voltage. The power supply is fan cooled to increase reliability. The module supplies +12 V, +5 V, and +10 V for the PA (TX).



Universal Input: 90-260 VAC, 47-63 Hz.

Typical Power Consumption:
Transmitter: 80 Watts
Receiver: 45 Watts

Status LED's:
ANLG – Green Indicates +12V OK
DGTL - Green Indicates +5V OK

Figure 3-1 SL9003Q AC Power Supply

CAUTION

High voltage is present when the unit is plugged in.

To prevent electrical shock, unplug the power cable before servicing.

Power supply module should be serviced by qualified personnel only.

3.1.2.1. DC Input Option

An optional DC input power supply is available for the SL9003Q TX and RX, using a high reliability, DC-DC converter capable of operation from an input range from 20 - 72 VDC. The power supply contains two DC-DC converters; the first regulates to 12V; the second supplies 5V. An additional regulator supplies 10V for the PA (TX).

The DC input is isolated from chassis ground and can be operated in a positive or negative ground configuration. The power supply module is removable from the unit and no high voltages are accessible.

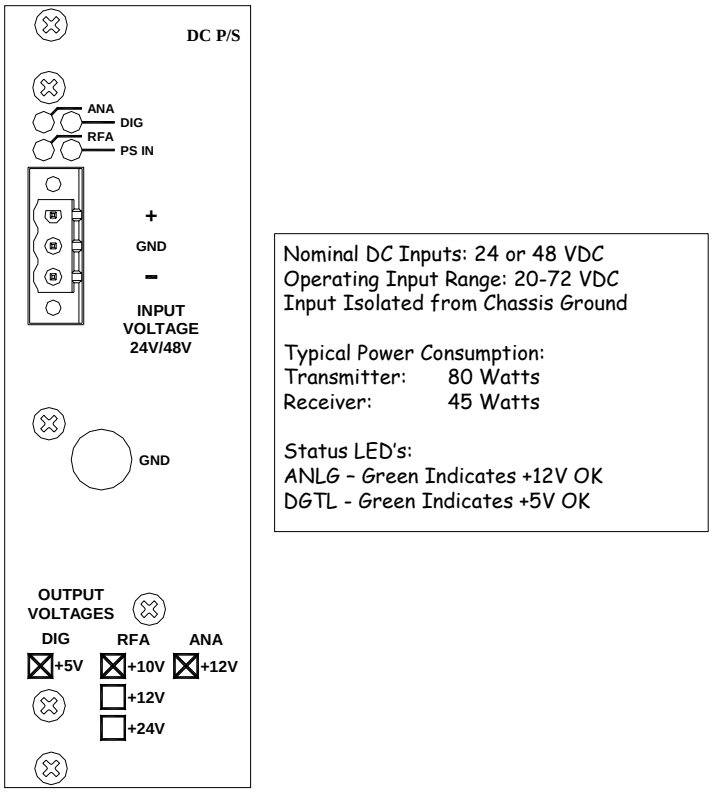


Figure 3-2 SL9003Q DC Power Supply

3.1.2.2. Fusing

For AC modules, the main input fuse is located on the switching power supply mounted to the carrier PC board and the protective cage may be removed for access to the fuse.

For DC modules, all fusing is located on the carrier PC board.

Always replace any fuse with same type and rating. Other fuses are present on the board, and are designed for output fail-safe protection of the system. All output fuse values are printed on the back side of the PC board to aid in replacement.

NOTE:

If a fuse does blow in operation, investigate the possible cause of the failure prior to replacing the fuse, as there is adequate built-in protection margin.

3.2 Preliminary Bench Tests

It is best to perform back-to-back tests of the entire system while the user has both Transmitter and Receiver at the same location, prior to installation at the site. Digital STL's have different parameters for system checks than analog STL's.

Back-to-back bench testing is a good way to familiarize the user with the SL9003Q Discrete Audio and Composite systems. Also, the user will gain greater confidence in the configuration and likely save a few trips to the transmitter if the actual interconnecting equipment (such as the remote control equipment or stereo generator for the composite system) can be tested at this time as well.

Figures 3-3 and 3-4 show a typical setup for bench testing a complete Discrete Audio and Composite system respectively.

Caution

■ ***Always operate the transmitter terminated into a proper 50 ohm load.***

■ ***Always attenuate the signal into the receiver to less than 3000 microvolts.***

(Failure to observe the above precautions can cause the transmitter final amplifier to be destroyed or the receiver preamplifier to be damaged)

■ ***Avoid excessive pressure on the audio adjustment potentiometers located on the back panels of the audio encoder/decoder modules.***

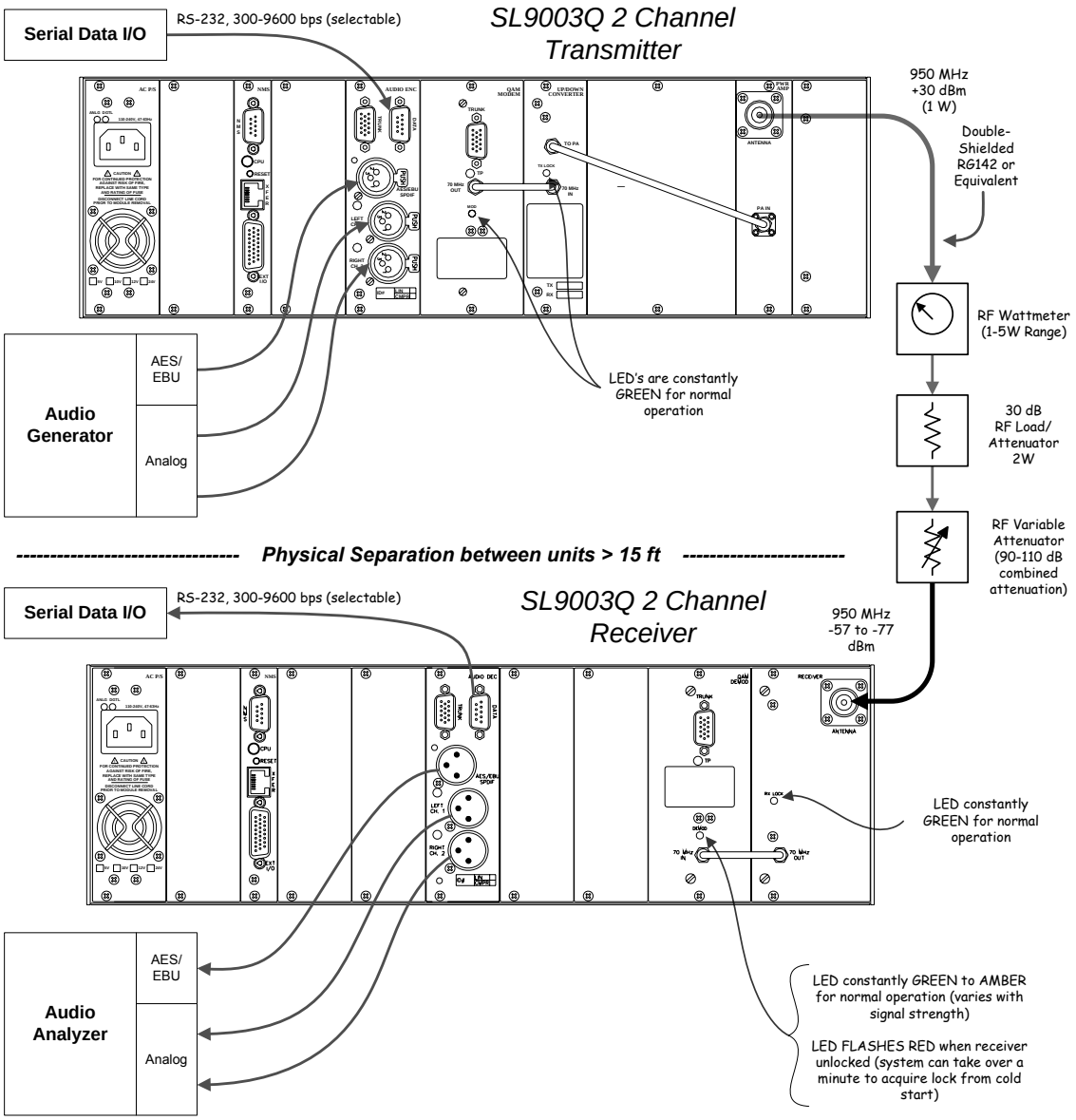

Serial Data I/O
RS-232, 300-9600 bps (selectable)
SL9003Q 2 Channel Transmitter
950 MHz +30 dBm (1 W)
Double-Shielded RG142 or Equivalent
RF Wattmeter (1-5W Range)
30 dB RF Load/ Attenuator 2W
RF Variable Attenuator (90-110 dB combined attenuation)
Audio Generator
AES/ EBU
Analog
LED's are constantly GREEN for normal operation
Physical Separation between units > 15 ft
Serial Data I/O
RS-232, 300-9600 bps (selectable)
SL9003Q 2 Channel Receiver
950 MHz -57 to -77 dBm
LED constantly GREEN for normal operation
Audio Analyzer
AES/ EBU
Analog
LED constantly GREEN to AMBER for normal operation (varies with signal strength)
LED FLASHES RED when receiver unlocked (system can take over a minute to acquire lock from cold start)

Figure 3-3 SL9003Q Discrete Audio Bench Test Setup

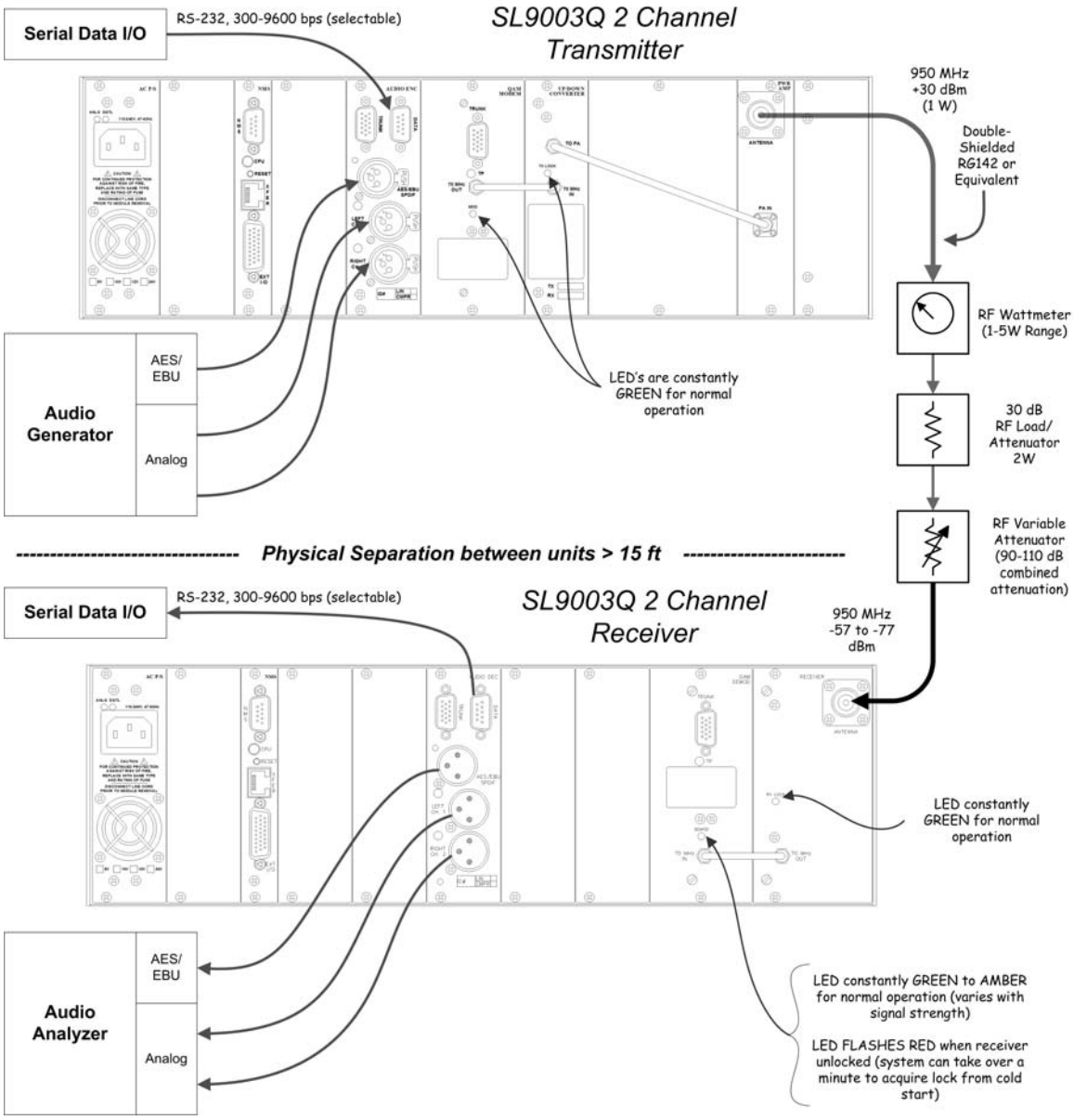

Serial Data I/O
RS-232, 300-9600 bps (selectable)
SL9003Q 2 Channel Transmitter
950 MHz +30 dBm (1 W)
Double-Shielded RG142 or Equivalent
RF Wattmeter (1-5W Range)
30 dB RF Load/ Attenuator 2W
RF Variable Attenuator (90-110 dB combined attenuation)
Audio Generator
AES/ EBU
Analog
LED's are constantly GREEN for normal operation
Physical Separation between units > 15 ft
Serial Data I/O
RS-232, 300-9600 bps (selectable)
SL9003Q 2 Channel Receiver
950 MHz -57 to -77 dBm
LED constantly GREEN for normal operation
Audio Analyzer
AES/ EBU
Analog
LED constantly GREEN to AMBER for normal operation (varies with signal strength)
LED FLASHES RED when receiver unlocked (system can take over a minute to acquire lock from cold start)

Figure 3-4 SL9003Q Digital Composite Bench Test Setup

3.2.1. RF Bench Test

Test Equipment

RF Wattmeter	950 MHz operation with a measurement range of 1–5 Watts
RF Power Attenuator	50 ohm, 5 watt “dummy load” for 950 MHz operation with 20 to 30 dB of attenuation
Variable Step Attenuator	0–100 dB at 950 MHz

Procedure

1. Connect the equipment as shown in Fig. 3-3 for a Discrete Audio link or Fig. 3-4 for a Digital Composite STL. Be sure to physically separate the TX and RX units by greater than 15 feet, in order to provide isolation for the BER threshold measurement. Calculate or measure the signal level present at the SL9003Q RX antenna input **(-60 dBm typical).**

2. Apply AC power to the SL9003Q receiver. On the Receiver module rear panel, the RX LOCK LED will light up red and change to green, indicating PLL lock of the down-converter. On the QAM Demod module rear panel, the DEMOD LED will flash red, indicating that there is no lock yet at the demod.

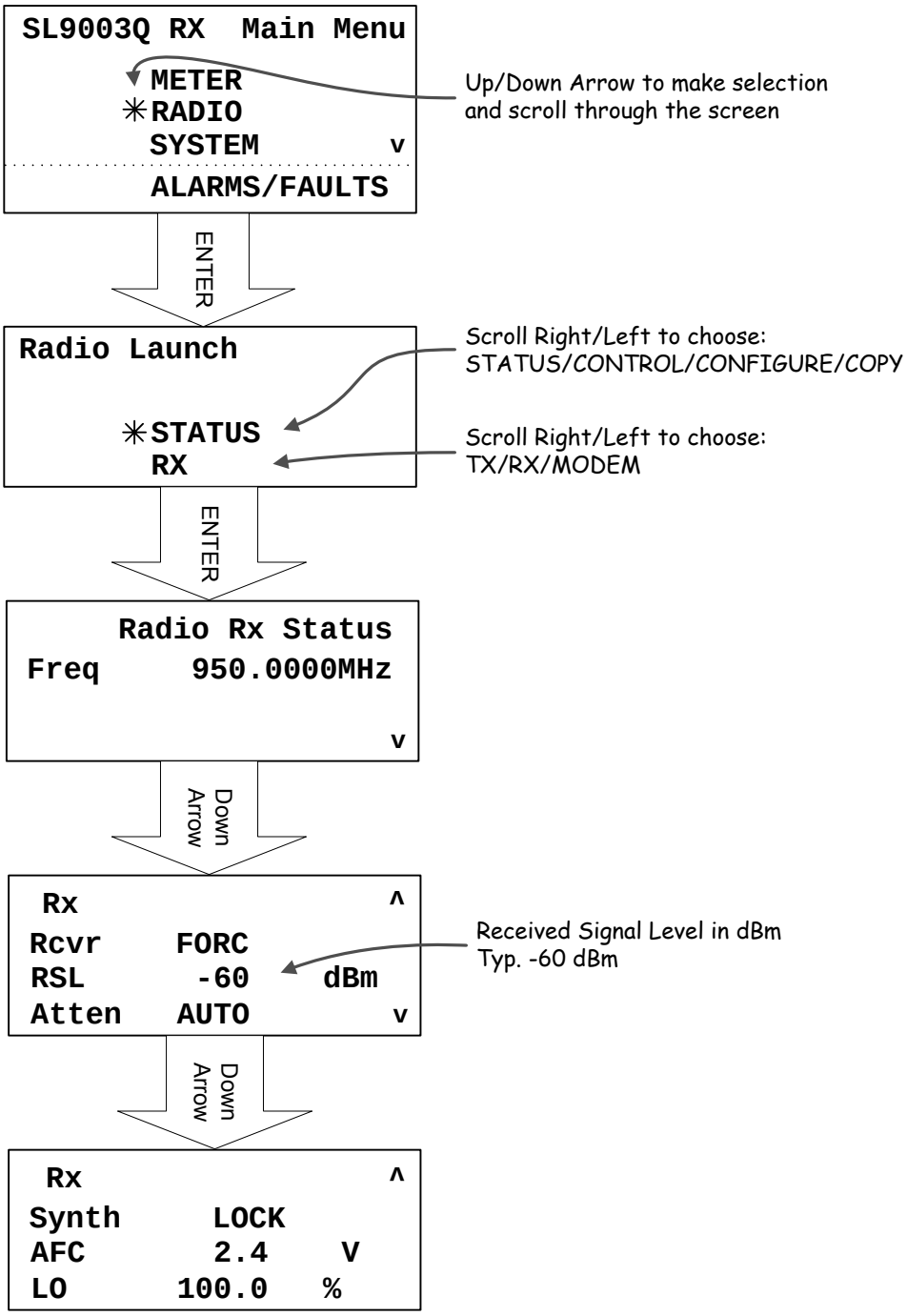
3. Apply AC power to the SL9003Q transmitter. On the Transmit Module rear panel, **the TX LOCK LED will light up red and change to green,** indicating PLL lock of the up-converter. On the QAM Mod module rear panel, **the MOD LED will flash red, and then change to green**, indicating lock of the QAM modulator.

4. The output power on the wattmeter should measure between 0.9 and 1.1 Watts.

5. Within 90 seconds after the TX carrier is present (30 sec. typical), the DEMOD LED will stop blinking and turn to a solid color:

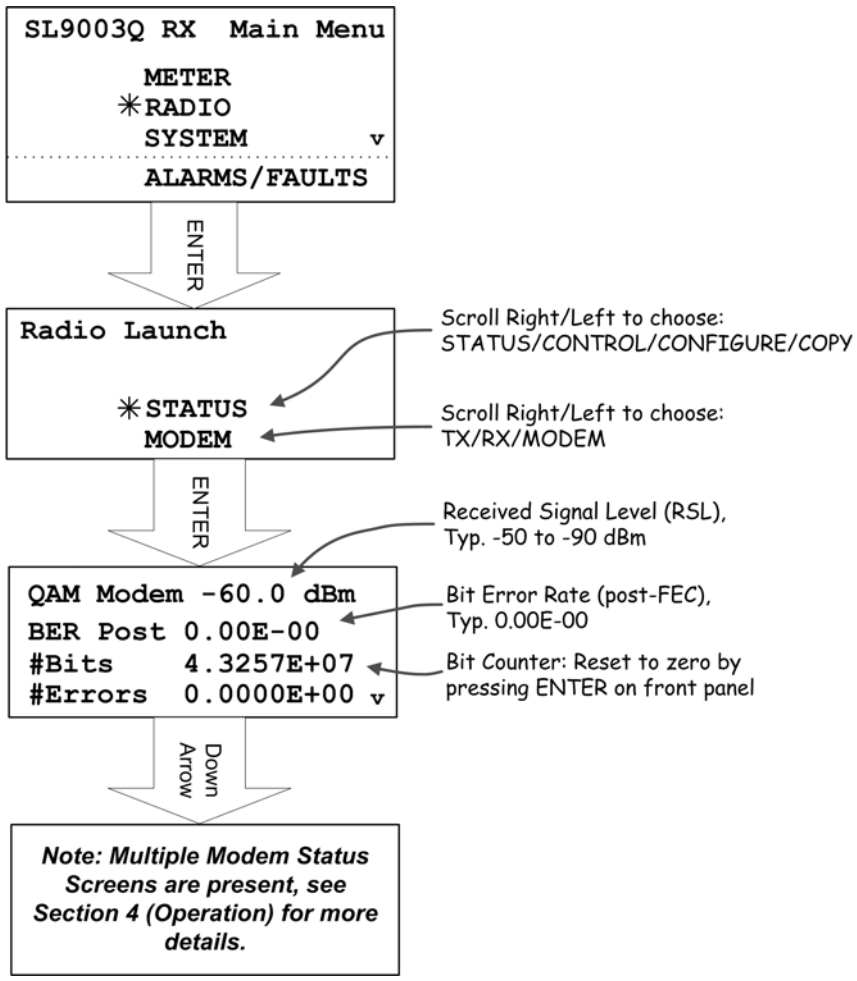
    - GREEN indicates high signal strength (ACCEPTABLE)
    - YELLOW indicates average signal strength (TYPICAL)
    - DARK ORANGE indicates low signal strength (ACCEPTABLE)
    - FLASHING RED indicates no signal (NON-OPERATIONAL)

6. After verifying the DEMOD LED is within the color range, go to the QAM RADIO RX STATUS screen on the front panel LCD display and page down to the RSL parameter (see below).



7. Verify that the RSL (Received Signal Level) is reading within 2 dB of the calculated value for your setup (-60 dBm typical).

8. Press ESC until you arrive at the Main Menu. Follow the screen navigation below to get to the QAM MODEM STATUS (Post-BER) screen on the front panel LCD display (see below).



9. With the POST-BER in the display, press ENTER. This will reset the bit counter (# BITS) to zero. **There should be no errors (# ERRORS = zero) under this signal condition.**

10. Verify BER threshold performance of the system as follows: Increase the variable attenuation until the QAM MODEM STATUS (BER POST) screen displays a **BER POST reading of approximately 1.00E-06.** This will take some time in order to accumulate enough bits for an accurate measurement.

11. The RSL reading should be approximately:

2 channel:	–89 dBm (+/- 2 dBm)
4 channel:	–89 dBm (+/- 2 dBm)
Composite:	–89 dBm (+/- 2 dBm)

12. Set the variable attenuator for a reading of -60 dBm on the display.

13. Reset the bit counter (press ENTER) and verify error-free operation

14. Proceed to the Audio Bench Test for further performance verification.

3.2.2. Discrete Audio and Data Channel Bench Test

Test Equipment

RF Wattmeter	950 MHz operation with a measurement range of 1–5 Watts
RF Power Attenuator	50 ohm, 5 watt "dummy load" for 950 MHz operation with 20 to 30 dB of attenuation
Variable Step Attenuator	0–100 dB at 950 MHz
Serial I/O Data	RS232, 300-9600 bps; (equivalent to the subcarrier data port that will be used in the site installation - use the actual remote control equipment if possible)
Audio Distortion Analyzer	AES/EBU digital audio I/O is desirable. (Test equipment will allow adjustment of levels for calibration check.)

Procedure

1. Connect the equipment as shown in Fig. 3-3. Be sure to physically separate the TX and RX units by greater than 15 feet.

2. Ensure the link is RF operational as outlined in the RF Bench Test (Section 3.2.1). **Adjust the attenuator for an RSL reading of –60 dBm +/- 2 dBm and verify error-free operation.**

3. Ensure that the appropriate module ID# is selected in both the Transmitter and Receiver Units' (in the METER LCD screen).

4. **AES/EBU Digital Audio Test**: Apply a 1kHz stereo tone, at a level of 0 dB (full scale), to the Source Encoder module.

5. The front panel bar graph of the transmitter and the receiver should register a 0 dB reading for both channels.

6. **Analog In/Out Audio Test:** Be sure there is no AES signal at the module in order to force the auto-switching circuitry to the analog inputs. Next, apply a 1 kHz tone, at a level of +10dBm, to the left (CH.1) channel.

7. The front panel bar graph of the transmitter and the receiver should register a 0 dB reading for Channel 1.

8. Measure the audio frequency response:
32 kHz sample rate: 5 Hz-15 kHz +/- 0.2 dB
44.1 kHz sample rate: 5 Hz-20 kHz +/- 0.2 dB
48 kHz sample rate: 5 Hz-22.5 kHz +/- 0.2 dB

9. Signal to Noise: Measure the 1 kHz level and set a reference for an SNR measurement.

10. Disconnect or disable the tone at the encoder input and measure the SNR of the system:
AES/EBU in/out: < -90 dB (-92 typ.) Linear/Compressed
ANALOG in/out: < -82 dB (-84 typ.) Linear/Compressed

11. Reapply the 1 kHz tone and measure THD:
Linear, AES/EBU: <0.01% (.0025% typ.)
Linear, Analog: <0.01% (.008% typ.)
MPEG, AES/EBU: <0.01% (.003% @ 1kHz typ.)
MPEG, Analog: <0.015% (.012% @ 1kHz typ.)

NOTE: *The static distortion measurement of MPEG compressed audio is erroneous in the fact that the compression algorithm is dependent upon dynamic audio level changes (i.e., music). The subjective aural distortion is much lower. The static measurement is also dependent on frequency (.007 % typ @ 7-12kHz). The above values are typical at 1kHz and will provide excellent on-air performance.*

3.2.3. Digital Composite and Data Channel Bench Test

Test Equipment

RF Wattmeter	950 MHz operation with a measurement range of 1–5 Watts
RF Power Attenuator	50 ohm, 5 watt “dummy load” for 950 MHz operation with 20 to 30 dB of attenuation
Variable Step Attenuator	0–100 dB at 950 MHz
Serial I/O Data	RS232, 300-9600 bps; (equivalent to the subcarrier data port that will be used in the site installation, use the actual remote control equipment if possible)
FM STereo generator	optional - digital stereo generator (Orban 8202 or equivalent)
FM stereo monitor	optional - digital stereo demodulator (belar fmsa-1 or equivalent)
Audio Distortion Analyzer	AES/EBU digital audio I/O is desirable. (Test equipment will allow adjustment of levels for calibration check.)

Procedure

1. Connect the equipment as shown in Fig. 3-4. Be sure to physically separate the TX and RX units by greater than 15 feet.

2. Ensure the link is RF operational as outlined in the RF Bench Test (Section 3.2.1). **Adjust the attenuator for an RSL reading of –60 dBm +/- 2 dBm and verify error-free operation.**

3. **Composite Test:** Apply a 400 Hz stereo tone, at a level of 0 dB (full scale), to the left and right channels of the FM Stereo Generator for 100% modulation. (Some digital stereo generators use –2.75 dB to represent 100% full scale, consult your manufacturer's information.)

4. Apply the composite signal, 100% modulation at 3.5 Vp-p to the composite input of the transmitter. (Alternatively apply 3.5Vp-p 400 Hz tone directly from the audio generator to check levels only).

5. The front panel bar graph of both the transmitter and the receiver should register a -3 dB reading (YELLOW LED) for both Channel 1 and Channel 2. A slight increase in level should indicate 0 dB reading (RED LED). (Note: There is exactly 2 dB of headroom above the 0 dB indication (RED LED) before the A/D input clips).

6. Separation: Measure the 400 Hz level and set a reference for left and right channels.

7. Disconnect the tone on the right channel to the stereo generator and measure the level in the right channel.

   Left-to-Right Separation: > 65 dB

8. Signal to Noise: Disconnect the tone on the left channel to the stereo generator and measure the SNR.

   L/R SNR: > 82 dB (85 typ).

9. Reapply the 400 Hz tone and measure THD.

   L/R THD: <0.035%

10. **Composite Data Test:** Apply the RS-232 data source to the 9-pin CHANNEL 1 connector on the Starlink transmitter and the RS-232 data receiving unit to the

CHANNEL 1 connector on the receiver. Default interface is 300 baud, 8 bit, odd parity. Confirm data is properly received through the radio.

This completes the bench tests for the SL9003Q system. If you have any problems or discrepancies, please consult the Test Data Sheet to check factory readings. If there is still a problem, please call Moseley Technical Services (see Section 6).

3.3 Site Installation

The installation of the SL9003Q involves several considerations. A proper installation is usually preceded by a pre-installation site survey of the facilities. The purpose of this survey is to familiarize the customer with the basic requirements needed for the installation to go smoothly. The following are some considerations to be addressed (refer to Figure 3-5 for Receiver Site Installation Details).

Before taking the SL9003Q to the installation site verify that the audio connections are compatible with the equipment to be connected. Also, locate the information provided by the path analysis which should have been performed prior to ordering the equipment. At the installation site, particular care should be taken in locating the SL9003Q in an area where it is protected from the weather and as close to the antenna as possible. Locate the power source and verify that it is suitable for proper installation.

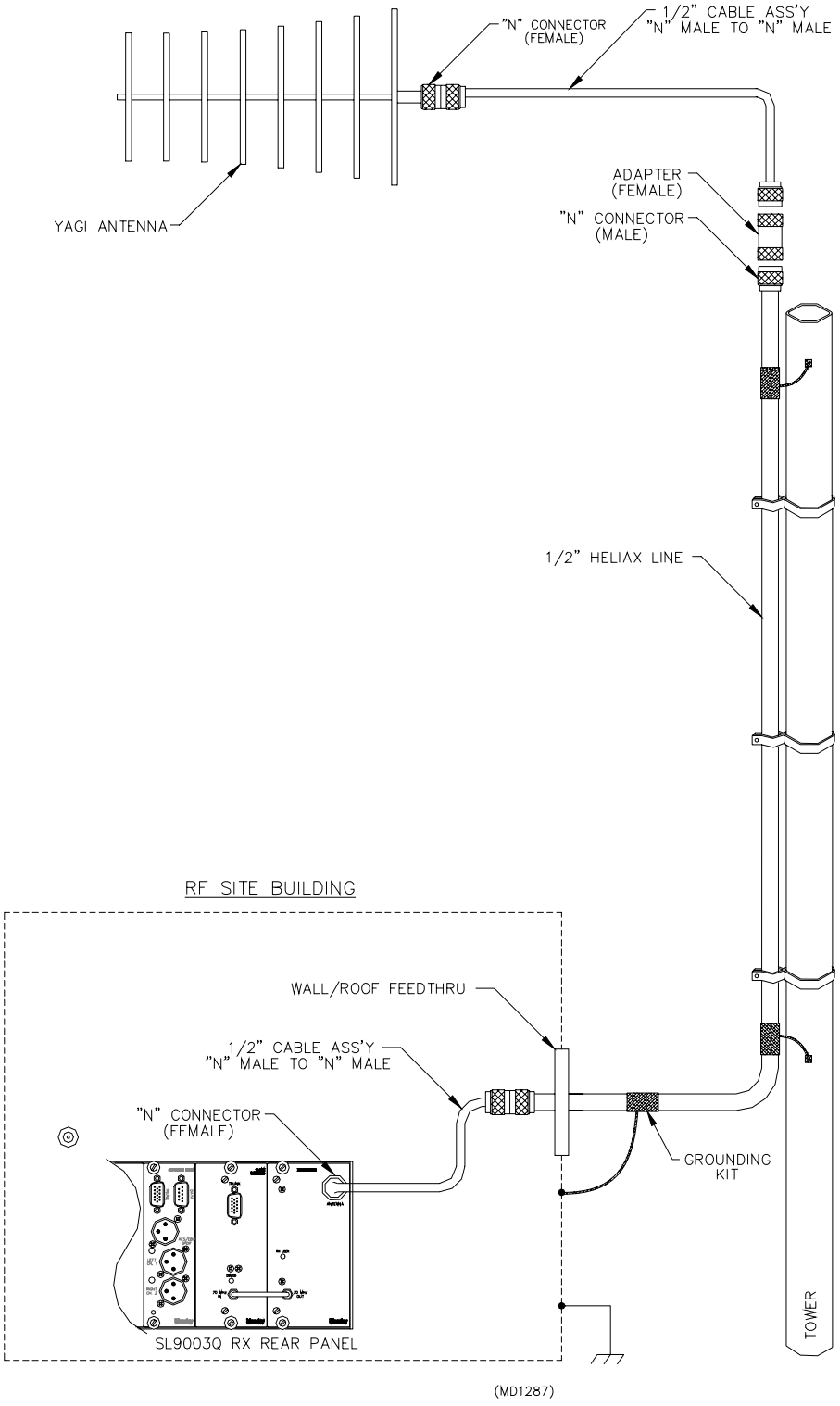


Figure 3-5 Receiver Site Installation Details

3.3.1. Facility Requirements

The site selected to house the SL9003Q should follow conventional microwave practice and should be located as close to the antenna as possible. This will reduce the RF transmission line losses, minimize possible bending and kinking of the line, and allow for the full range potential of the radio link.

The building or room chosen for installation should be free from excessive dust and moisture. The area should not exceed the recommended temperature range, allow for ample air flow, and provide room for service access to cables and wiring.

3.3.2. Power Requirements

The AC power supply uses a universal input switching supply that is adaptable to power sources found worldwide. The line cord is IEC (USA) compatible, and the user may need to adapt to the proper physical AC connector in use.

For DC input units, double-check the input voltage marking on the rear panel does indeed match the voltage range provided by the facility. Verify that the power system used at the installation site provides a proper earth ground. The DC option for the SL9003Q have isolated inputs by default, but the user may hard-wire a negative chassis ground inside the module, if desired.

An uninterruptible power supply backup (UPS) system is recommended for remote locations that may have unreliable source power. Lightning protection devices are highly recommended for the power sources and antenna feeds.

3.3.3. Rack Mount Installation

The SL9003Q is designed for mounting in standard 19” rack cabinets, using the rack ear brackets included with the SL9003Q. The rack ear kit is designed to allow flush mount or telecom-mount (front extended). See Figure 3-6 for bracket installation. Be sure to provide adequate air space near the ventilation holes of the chassis (top, bottom, and sides).

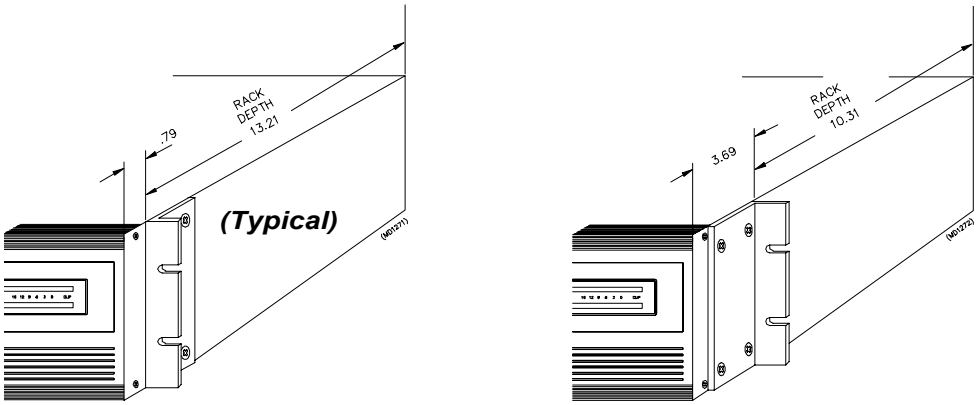


Figure 3-6 Rack Ear Bracket Mounting Methods

3.4 Antenna/Feed System

3.4.1. Antenna Mounting

The antennas used as part of the SL9003Q system are directional. The energy radiated is focused into a narrow beam by the transmitting antenna and must be aligned towards the receiving antenna. The type of antenna used in a particular installation will depend on frequency band and antenna gain requirements. These parameters are determined by the path analysis.

The antenna is usually mounted on a pipe mount or tower, on top of a building, on a tower adjacent to building where the SL9003Q is installed, or on some structure that will provide the proper elevation. If the tower or antenna mounting mast is to be mounted on a building, an engineer should be consulted to ensure structural integrity. The antenna support structure must be able to withstand high winds, ice, and rain without deflecting more than one tenth of a degree. The optimum elevation is determined by the path analysis.

Mount the antenna onto its mounting structure but do not completely tighten the mounting bolts at this time. The antenna will need to be rotated during the path aligning process.

Information on how to perform a site survey and path analysis can be found in the Appendix, Path Evaluation Information.

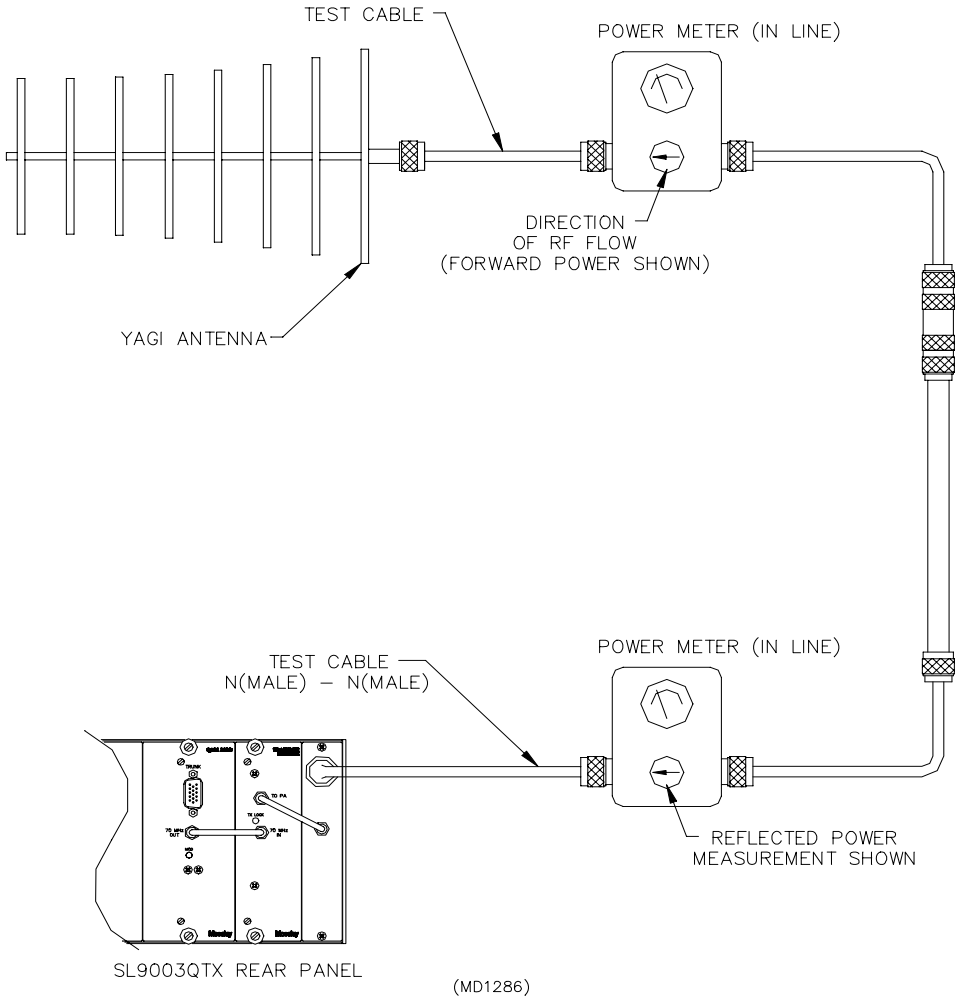
3.4.2. Transmission Line

Run the transmission line in such a manner as to protect it from damage. Note that heliax transmission line requires special handling to keep it in good condition. It should be unreeled and laid out before running it between locations. It cannot be pulled off the reel the same way as electrical wire. Protect the line where it must run around sharp

edges to avoid damage. A kinked line indicates damage, so the damaged piece must be removed and a splice installed to couple the pieces together.

3.4.3. Environmental Seals

The connections at the antenna and the transmission line must be weather-sealed. This is best accomplished by completely wrapping each connection with Scotch #70 tape (or equivalent), pulling the tape tight as you wrap to create a sealed boot. Then, for mechanical protection over the sealed layer, completely wrap the connection again with Scotch #88 (or equivalent). Tape ends must be cut rather than torn—a torn end will unravel and work loose in the wind. Use plenty of tape for protection against water penetration and the premature replacement of the transmission line.



NOTES:
1. MEASURE FORWARD AND REFLECTED POWER AT TRANSMITTER AND ANTENNA TO DETERMINE LINE LOSSES.
2. REFLECTED POWER ≤ 5% OF FORWARD POWER.

Figure 3-7 Transmitter Antenna Testing

3.5 Transmitter Antenna Testing

After assuring that the SL9003Q is properly installed, attach the transmission line to the "N" connector labeled ANTENNA on the rear of the SL9003Q. Tighten the connector by hand until it is tight. Connect the appropriate audio and data cables to the ports on the rear panel.

After running the transmission line and fastening it in place, connect the antenna end of the transmission line to the antenna feed line, using a short coaxial jumper and a double female barrel adapter. Connect the radio end of the transmission line to a wattmeter (with appropriate frequency and power rating), using the radio feed line and another coaxial jumper (see Figure 3-7).

Note: Standard Wattmeters are calibrated for CW (carrier) power measurement. For QAM digital modulation, these wattmeters will indicate approx. 1/2 of the actual power.

Apply power to the SL9003Q and check the status indications for proper initial operation. Observe forward power, and check that reverse power is negligible. Turn off power to the radio.

Exchange the wattmeter with the barrel adapter and coaxial jumper at the antenna end of the transmission line. Power-up the radio.

Observe forward power to the antenna, and verify that power loss in the transmission line is within system specifications. Verify that reflected power from the antenna is negligible. Reflected power should be less than 5% of the forward value, and in most cases will be significantly less. Turn off power to the radio.

Disconnect the test equipment, reconnect the antenna feed lines, and proceed to link alignment.

3.6 Link Alignment

It is very important to aim the antennas properly; if the antennas are not aligned accurately, the system may not operate. An approximate alignment is achieved through careful physical aiming of the antennas toward each other. The receiver should indicate enough signal to operate when this is achieved.

Once an approximate alignment is achieved, align the antennas accurately by accessing the QAM RADIO MODEM STATUS (BER POST) screen and observe the RSL in dBm (upper right corner of display). This screen also displays Bit Error Rates, which is the primary parameter for system performance.

Turn the antenna in small increments until the maximum signal is displayed. Please note that the signal levels should agree with the initial path calculations plus or minus 6 dBm, or there may be a problem with antenna alignment or the antenna system. The #ERRORS display should be zero, while the #BITS is keeping a running count of the

data rate. By pressing ENTER while viewing the screen, the error count will reset to zero. This is useful while making antenna adjustments, as erroneous errors can be eliminated from the display for ease of use.

After peak alignment is achieved, tighten the bolts to hold the antenna securely. Double-check the RSL and BER STATUS indications. Link alignment is complete.

4 Operation

7.1 Introduction

This section describes the front panel operation of the SL9003Q digital radio/modem. This includes:

- LCD display (including all screen menus)
- Cursor and screen control buttons
- LED status indicators
- Bargraph Display

7.2 Front Panel Operation

A pictorial of the SL9003Q front panel is depicted in Figure 4-1 below. The LED status indicators are different for the transmitter, receiver or repeater; and are detailed in Section 4.2.3.

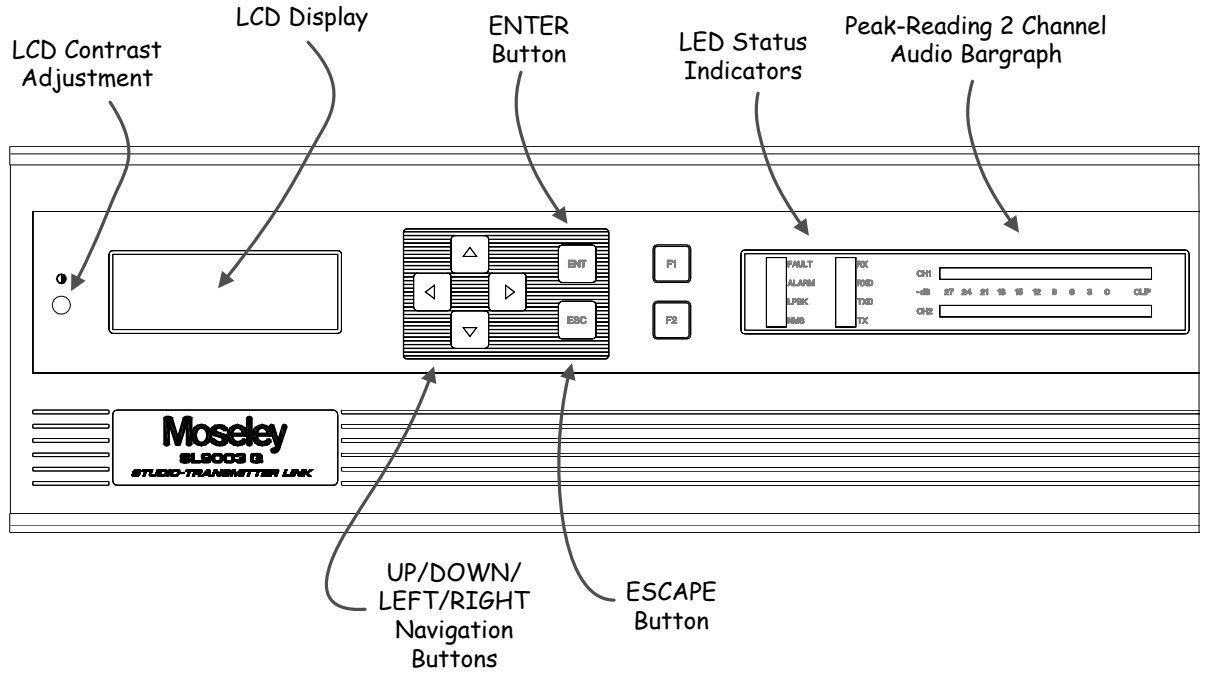


Figure 4-1 SL9003Q Front Panel

4.2.1 LCD Display

The Liquid Crystal Display (LCD) on the SL9003Q front panel is the primary user interface and provides status, control, configuration, and calibration functionality. The menu navigation and various screens are explained in detail later in this section.

Contrast Adjustment:
The contrast adjustment is front panel accessible (to the left of the LCD). A small flathead screwdriver may be used to adjust for optimum visual clarity.

4.2.2 Cursor and Screen Control Buttons

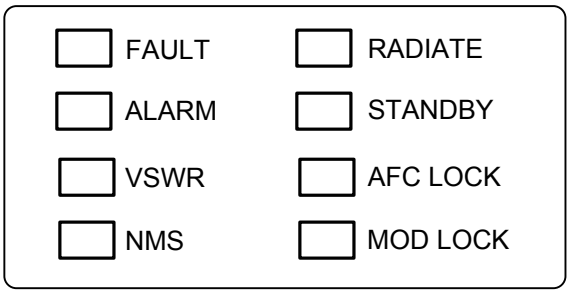
The buttons on the SL9003Q front panel are used for LCD screen interface and control functions:

ENT	**<ENTER>**	Used to accept an entry (such as a value, a condition, or a menu choice).
ESC	**<ESC>**	Used to "back up" a level in the menu structure without saving any current changes.
▲ ▼	**<UP>,<DOWN>**	Used in most cases to move between the menu items. If there is another menu in the sequence when the bottom of a menu is reached, the display will automatically scroll to that menu.
◀ ▶	**<LEFT>,<RIGHT>**	Used to select between conditions (such as ON/OFF, ENABLED/DISABLED, LOW/HIGH, etc.) as well as to increase or decrease numerical values.
F1 F2	**<F1>,<F2>**	Software programmable buttons (to be implemented in a later software revision)

4.2.3 LED Status Indicators

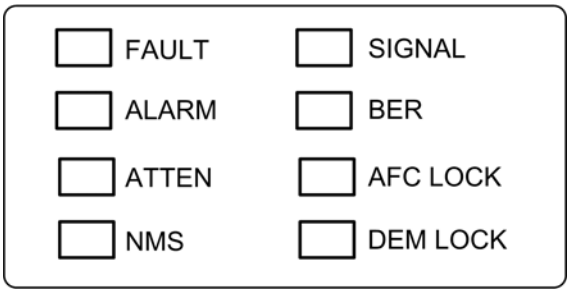
There are eight status indicator LED's on the SL9003Q front panel. Their functions are listed in Table 4-1 (Transmitter), Table 4-2 (Receiver) and Table 4-3 (Full Duplex Systems).

Table 4-1 LED Status Indicator Functions (Transmitter)



LED	Name	Function
FAULT	Fault	RED indicates that a parameter is out of tolerance and is crucial to proper system operation. If the fault corrects itself, the event will be logged, and the LED will turn off. See the Fault Log Page in the screen menu for a list of events.
ALARM	Alarm	YELLOW indicates that a parameter is out of tolerance, but is NOT crucial for proper system operation (cautionary only). If the alarm corrects itself, the event will be logged, and the LED will turn off. See the Alarm Log Page in the screen menu for a list of events.
VSWR	VSWR	RED indicates the reflected power at the antenna port is too high
NMS	NMS/CPU	GREEN indicates CPU is functional.
RADIATE	Radiate	GREEN indicates the transmitter is radiating, and the RF output (forward power) is above the factory-set threshold.
STANDBY	Standby	GREEN indicates is ready and able for radiate to be enabled.
AFC LOCK	AFC Lock	GREEN indicates the 1st LO is phase-locked.
MOD LOCK	Modulator Lock	GREEN indicates QAM modulator is locked and functional.

Table 4-2 LED Status Indicator Functions (Receiver)



LED	Name	Function
FAULT	Fault	RED indicates that a parameter is out of tolerance and is crucial to proper system operation. If the fault corrects itself, the event will be logged, and the LED will turn off. See the Fault Log Page in the screen menu for a list of events.
ALARM	Alarm	YELLOW indicates that a parameter is out of tolerance, but is NOT crucial for proper system operation (cautionary only). If the alarm corrects itself, the event will be logged, and the LED will turn off. See the Alarm Log Page in the screen menu for a list of events.
ATTEN	Attenuator	RED indicates front end attenuator is enabled.
NMS	NMS/CPU	GREEN indicates CPU is functional.
SIGNAL	Received Signal	GREEN indicates that the received signal level is above limit.
BER	Bit Error Rate	GREEN indicates that BER is within acceptable limits.
AFC LOCK	AFC Lock	GREEN indicates the 1st LO is phase-locked..
DEM LOCK	Demodulator Lock	GREEN indicates QAM Demodulator is locked and functional.

Table 4-3 LED Status Indicator Functions (Repeater/Full Duplex Systems)

LED	Name	Function
FAULT	Fault	RED indicates that a parameter is out of tolerance and is crucial to proper system operation. If the fault corrects itself, the event will be logged, and the LED will turn off. See the Fault Log Page in the screen menu for a list of events.
ALARM	Alarm	YELLOW indicates that a parameter is out of tolerance, but is NOT crucial for proper system operation (cautionary only). If the alarm corrects itself, the event will be logged, and the LED will turn off. See the Alarm Log Page in the screen menu for a list of events.
LPBK	Loopback	RED indicates analog or digital loopback is enabled.
NMS	NMS/CPU	GREEN indicates CPU is functional.
RX	RX Receiver	GREEN indicates that the receiver is enabled, the synthesizer is phase-locked, and a signal is being received.
RXD	RXD Receive Data	GREEN indicates that valid data is being received.
TXD	TXD Transmit Data	GREEN indicates the modem clock is phase-locked and data is being sent.
TX	TX Transmitter	GREEN indicates the transmitter is radiating, and the RF output (forward power) is above the factory-set threshold.

4.3 Screen Menu Navigation and Structure

4.3.1 Screen Menu Navigation

Main Menu
The main menu appears on system boot-up, and is the starting point for all screen navigation. Unlike most other screens in the software, the main menu scrolls up or down, one line item at a time.

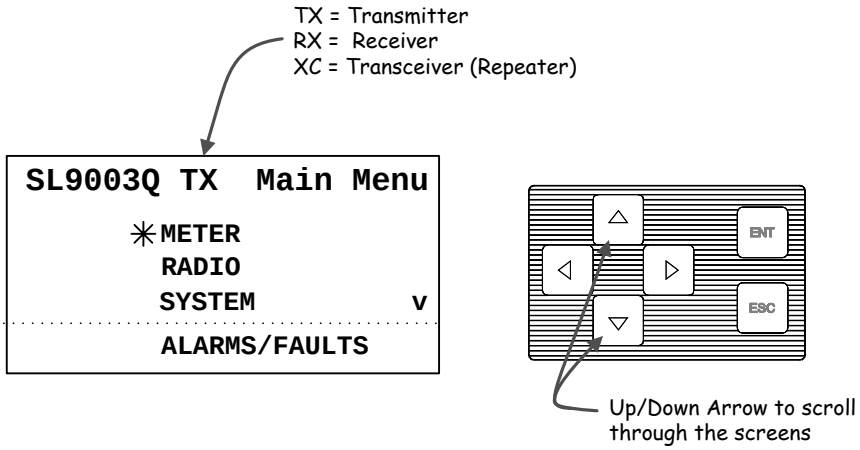


Figure 4-2 Main Menu Screen

Radio Launch Screen
The RADIO LAUNCH screen allows the user to quickly get to a particular screen within a functional grouping in the unit. The logic is slightly different than other screens. Figure 4-3 (below) shows the details for locating the desired Radio Screen.

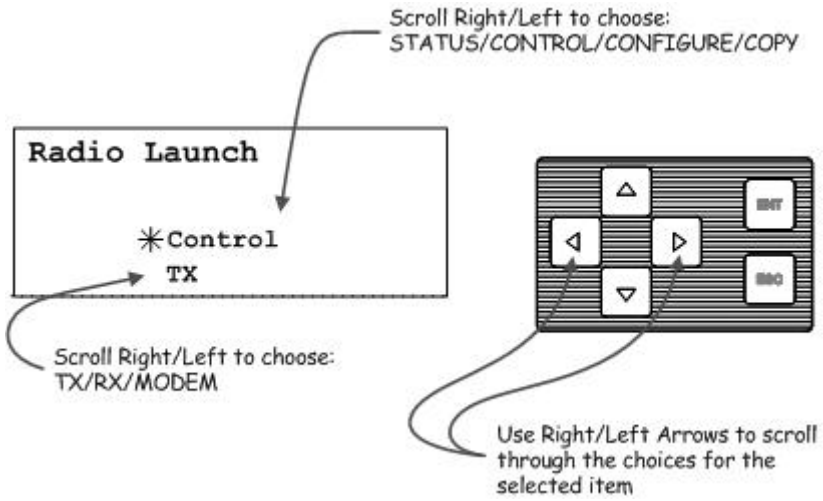
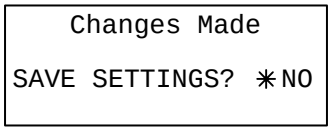


Figure 4-3 Radio Launch Menu Screen Navigation

4.3.2 Saving Settings (system-wide)



The "Save Settings" screen will appear after the user has made some kind of change using either a configure or control screen.

If this screen appears, and the user did not intend to change anything, then select NO (using the RIGHT/LEFT arrows) and press ENTER.

CAUTION:

This is a system-wide choice. If "YES" is selected, and ENTER is pressed, any settings that were changed since the last save WILL BE SAVED to power-on memory.

NOTE:

Most settings in the Configuration Screens will cause that setting to change immediately. HOWEVER, if the user chooses "NO" (above), then a power reset will bring the unit back to the previous settings.

4.3.3 Screen Menu Structure

Figures 4-4 shows the top level tree structure of the screen menu system. Go to the indicated section for the selected LCD Screen Menu.

In general, **<ENTER>** will take you to the next screen from a menu choice, **<UP>** or **<DOWN>** will scroll through screens within a menu choice, and **<ESC>** will take you back up one menu level. Certain configuration screens have exceptions to this rule, and are noted later in this section.

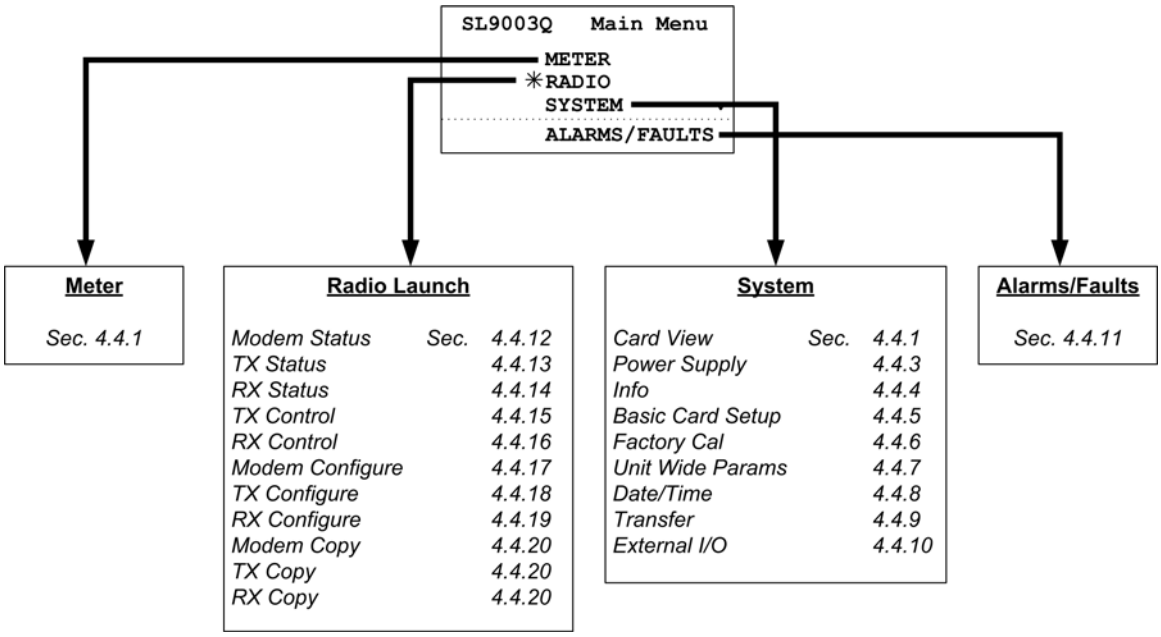


Figure 4-4 Top Level Screen Menu Structure

Note: There may be minor differences in the purchased unit, due to software enhancements and revisions. The current software revision may be noted in the **SYSTEM** sub-menu (under **INFO**).

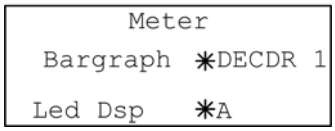
CAUTION

DO NOT change any settings in the CONFIGURE or CALIBRATE screens. The security lock-out features of the software may not be fully implemented, and changing a setting will most likely render the system non-operational!

7.4 Screen Menu Summaries

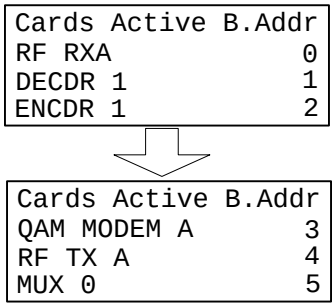
The following tables and text provide a screen view for that topic as well as the functions and settings of that screen. A summary of each function and the user manual location for additional information is also provided.

4.4.1 Meter



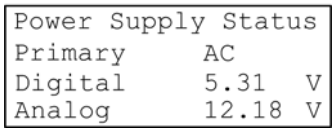
Function	Settings	Summary
Bargraph	ENCDR1, 2, … DECDR1, 2, … NONE	Selects the desired audio source for display on the audio level bargraph Turns off the bargraph
Led Dsp	A B	Used for future option

4.4.2 System: Card View



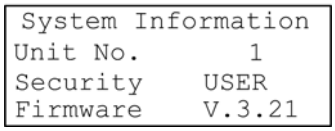
Function	Settings	Summary
Cards Active	RF RXA	QAM Receiver RF Module installed in QAM Radio “A” slots (base address 0)
	DECDR 1	Audio Decoder #1 installed (base address 1)
	ENCDR 1	Audio Encoder #1 installed (base address 2)
	QAM MODEM A	QAM Modem Module installed in QAM Radio “A” slots (base address 3)
	RF TX A	QAM Transmitter RF Module installed in QAM “A” slots (base address 4)
	MUX	Intelligent Multiplexer #0 installed (base address 5)
Note: The card view screen gives the user a list of all installed cards in the unit. The base address (B. Addr) is listed for diagnostic purposes only.		

4.4.3 System: Power Supply



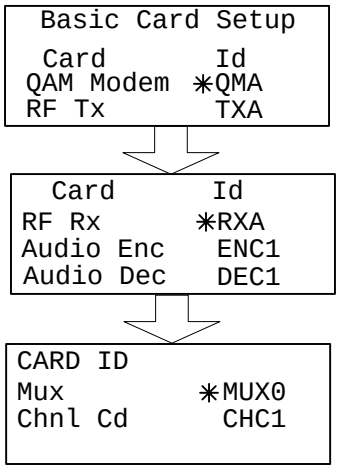
Function	Settings	Summary
Primary	 AC DC	Indicates type of supply: Universal AC input DC Option
DIGITAL	5.20 V nominal	Voltage level of the main +5 volt supply
ANALOG	12.00 V nominal	Voltage level of the main +12 volt supply. (12V is regulated to 10V for Power Amplifier but not monitored)

4.4.4 System: Info



Function	Settings	Summary
Unit No.	1-255	Defines Unit # for network ID
SECURITY	 Lockout User (default) Factory	Indicates access level of security: No control available Limited control of parameters Full configure and calibration
FIRMWARE	V.x.xx	Revision of front panel screen menu software

4.4.5 System: Basic Card Setup



Function	Settings	Summary
QAM Modem	QMA, QMB	QAM Modem installed in QAM Radio slots A or B
RF Tx	TXA, TXB	QAM Transmitter installed in QAM Radio slots A or B
AUDIO ENC	ENC1,2,…	Audio Encoder installed and identified (affects meter selection of bargraph)
AUDIO DEC	DEC1,2,…	Audio Decoder installed and identified (affects meter selection of bargraph)
MUX	MUX 0,1,…	Mux Module installed and identified
Chnl Cd	CHC 1,2,…	Channel Card installed and identified
Note: These are factory settings of installed cards, used to control appropriate displays in the CARD VIEW screens.		

4.4.6 Factory Calibration

The Factory Calibration Screens are documented below. The user may refer to this diagram when instructed to do so by Moseley customer service technicians.

Though the user is given access to the factory calibration menu area to allow for field servicing and monitoring of certain measurements, be aware that changing any parameter (pressing ENTER) may cause the units to fail to operate properly.

Caution

Changing Factory Calibration may cause the link to fail. Do not change unless directed by Moseley Customer Services personnel

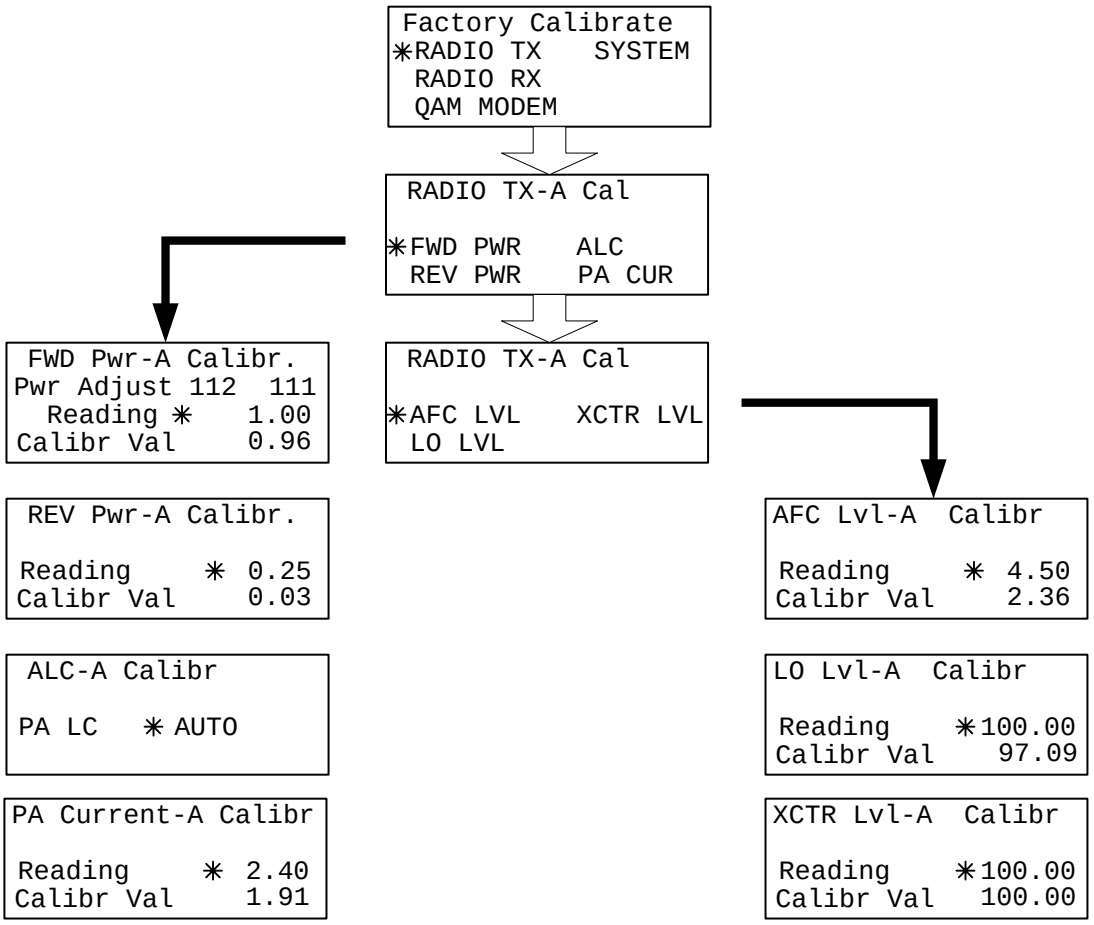


Figure 4-5 Factory Calibration-Radio TX Screens

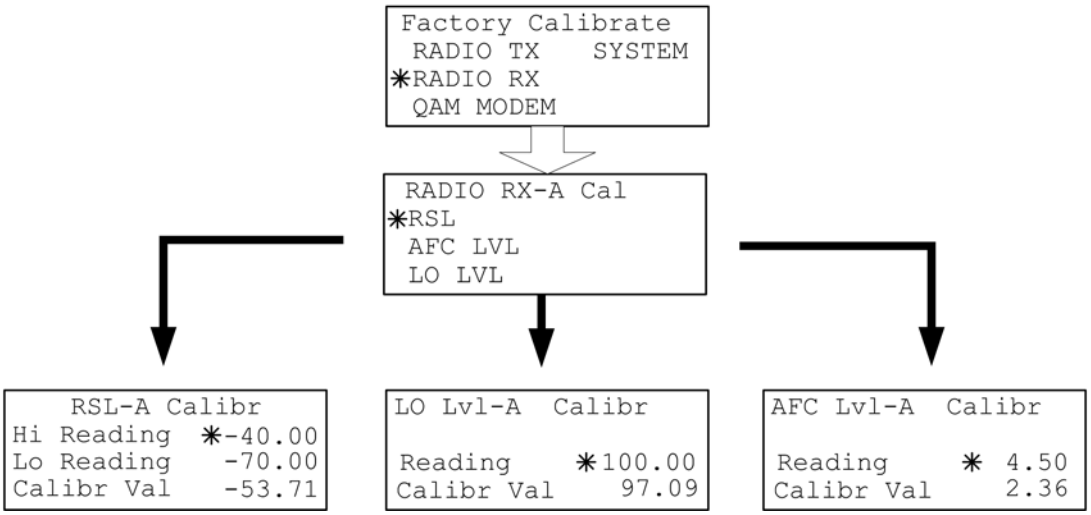


Figure 4-6 Factory Calibration-Radio RX Screens

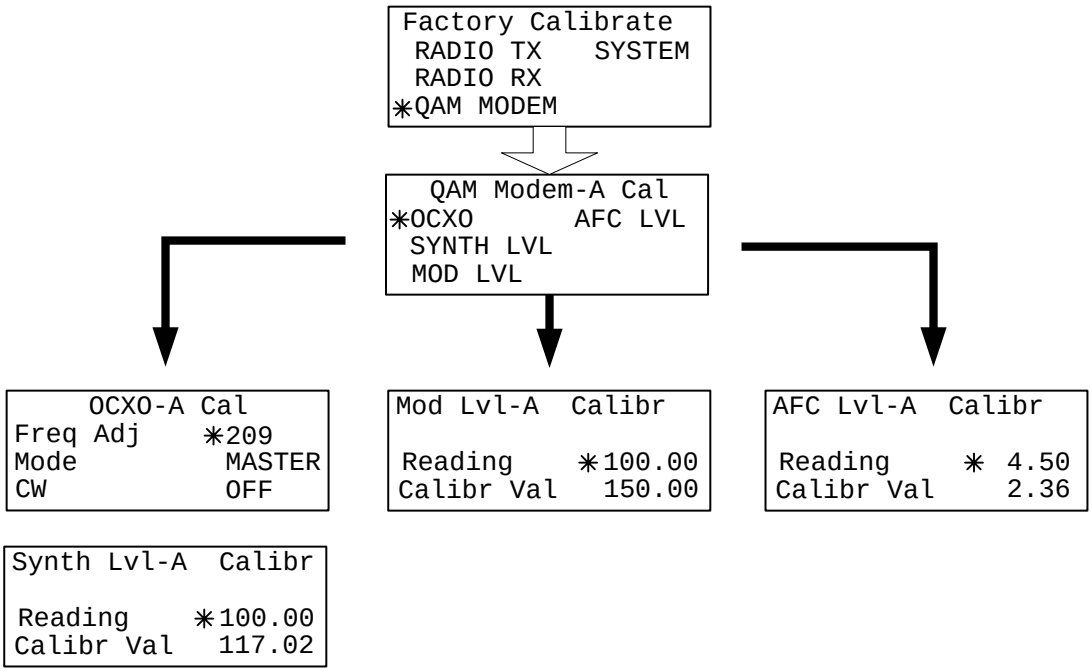


Figure 4-7 Factory Calibration-QAM Modem Screens

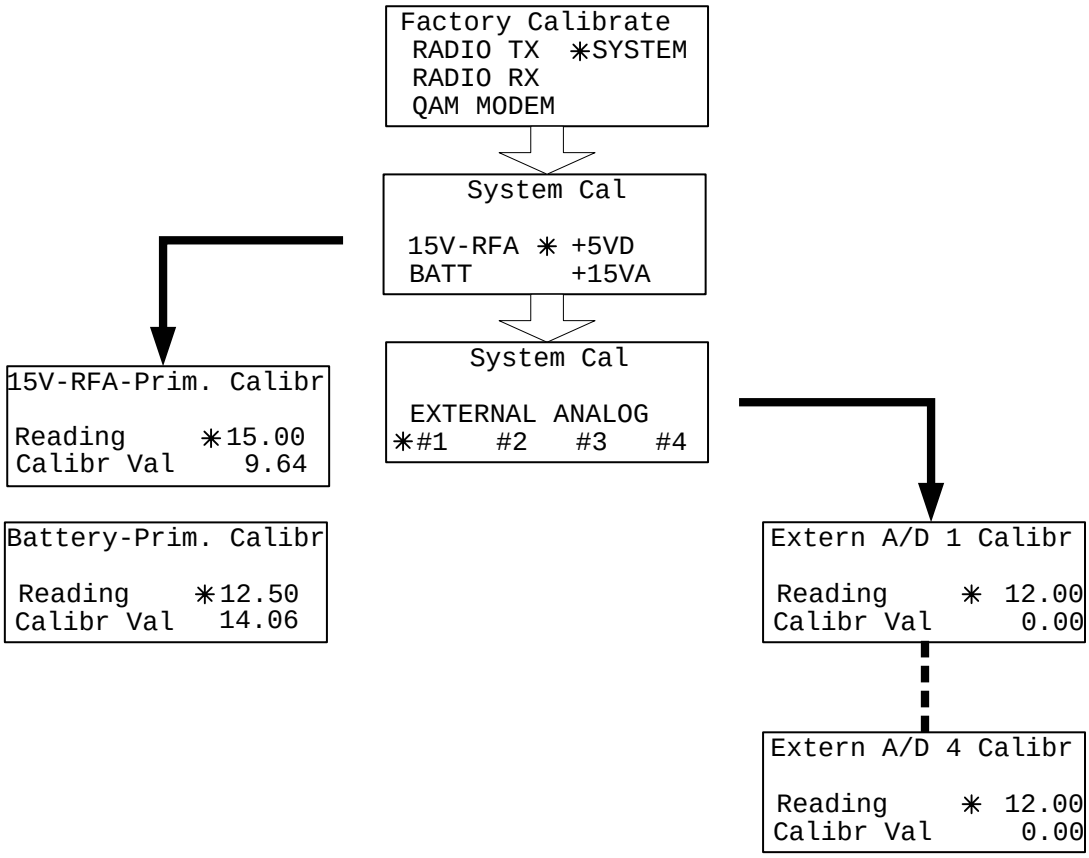
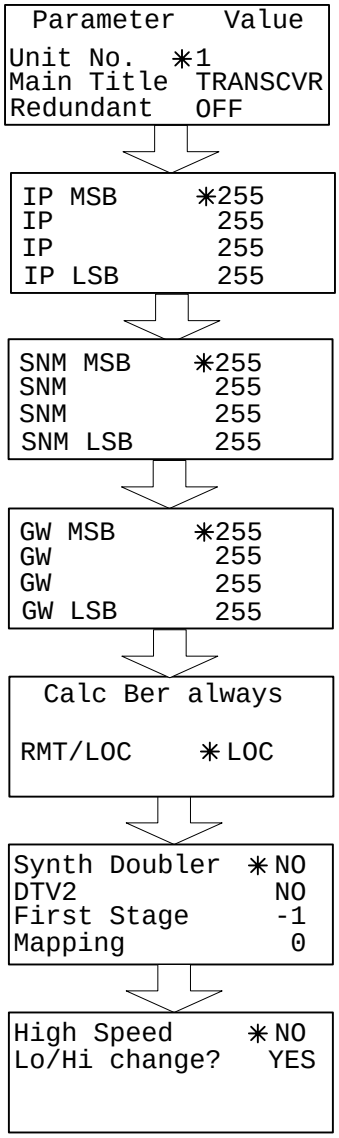


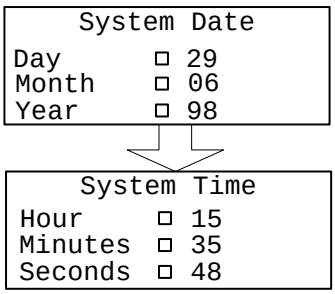
Figure 4-8 Factory Calibration-System Screens

4.4.7 SYSTEM: UNIT-WIDE PARAMS



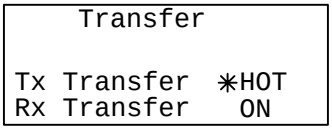
Function	Settings	Summary
Unit No	1-255	Defines Unit # for network ID
MAIN TITLE	TRANSMITTER RECEIVER TRANSCEIVER T1 DTV Link NXE1 DS3 TX DS3 RX DS3 XC EXP RX EXP TX	Determines main menu display and affects screen menu selection of modules
Redundant	OFF ON	Chooses redundant supply option
IP MSB **IP** **IP LSB** **SNM MSB** **SNM** **SNM LSB** **GW MSB** **GW** **GW LSB**	1-255	IP address settings (w/ SNMP option installed)
Calc Ber always	RMT LOC	IP address settings (w/ SNMP option installed)
Synth Doubler	Yes No	Setting for > 2 GHz operation
DTV2	YES NO EXP	Option setting
First Stage	-xxx to +xxx	Option setting
Mapping	0-3	External I/O Option setting
High Speed	Yes No	High Speed Modem Option
Lo/Hi Change?	Yes No	Locks out user from changing the Low/High-side LO setting

4.4.8 System: Date/Time



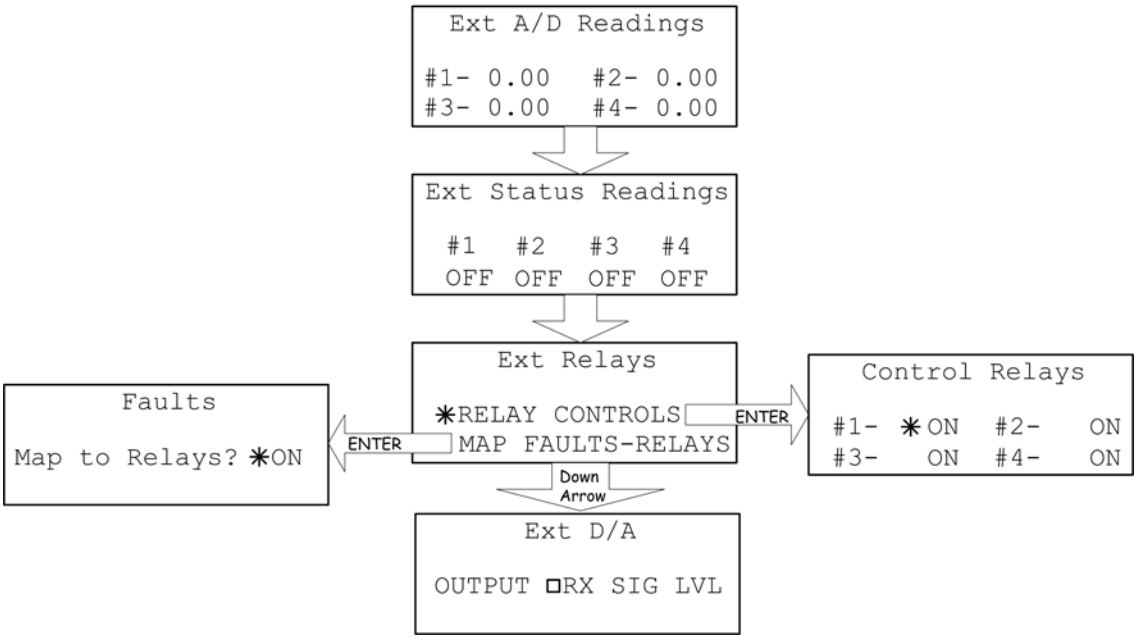
Function	Settings	Summary
Day **Month** **Year**	01-31 01-12 00-99	Sets the system date used for NMS and Fault/Alarm logging After selection, press ENTER to save
Hour **Minutes** **Seconds**	00-23 00-59 00-59	Sets the system time used for NMS and Fault/Alarm logging After selection, press ENTER to save

4.4.9 System: Transfer



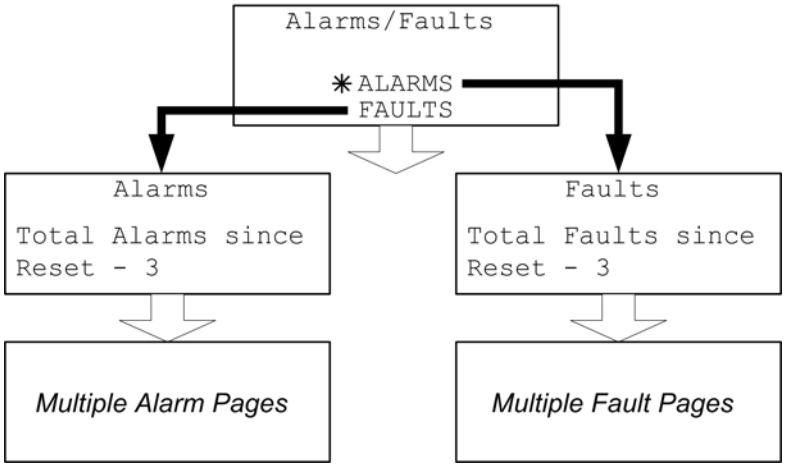
Function	Settings	Summary
Tx Transfer	 HOT COLD OFF	For external transfer panel setups (see Appendix) -Both TX on -Shuts PA off during standby -none
Rx Transfer	ON OFF	enables RX transfer

4.4.10 System: External I/O (NMS)



Function	Settings	Summary
Ext A/D Readings:	#1- 0.00 #2- 0.00 #3- 0.00 #4- 0.00	Monitors analog inputs #1, #2, #3, and #4 dc levels. (on pins 14, 13, 12, and 11, respectively of Ext I/O high-density connector).
Ext Status Readings:	#1- OFF #2- OFF #3- OFF #4- OFF	Monitors digital inputs #1, #2, #3, and #4 logic levels. (on pins 18, 17, 16, and 15, respectively of Ext I/O high-density connector).
Ext Relays	RELAY CONTROLS MAP FAULTS-RELAYS -Map to Relays? OFF/ON	Relay Controls: Manually force relay contacts closures for external relays #1,#2, #3, and #4. Map Faults-Relays: Maps fault logic to contact closures for ext. relays #1-#4. (on pin pairs 8-7, 6-5, 4-3, and 2-1 of Ext I/O high-density connector).
Ext D/A	OUTPUT *RX SIG LVL OUTPUT *TX FWD PWR OUTPUT *Rev PWR OUTPUT *BER	Controls monitoring output source of pin 10 on Ext I/O high-density connector. Receiver: Received Signal Level 0-5 Vdc Transmitter: Transmit Power 0-5 Vdc

4.4.11 Alarms/Faults



ALARMS

Module	Parameter	Nominal	Trip Value	LED Status
QAM RF TX	Reverse Power	0.05 Watt	> 0.25 Watt	VSWR
	PA Current	1.8 Amp	> 3.0 Amp	
	LO Level	100%	< 50%	
	Exciter Level	100%	< 50%	
QAM RF RX	RSL	-30 to –90 dBm		SIGNAL
	LO Level	100%	< 50%	
QAM MODEM	BER	-	>1.00E-04	MOD/DEM LOCK
	Synth Level	100%	< 50%	MOD/DEM LOCK
Modulator only	Modem Level	100%	< 50%	MOD/DEM LOCK

Alarm definition: A specific parameter is out of tolerance, but is NOT crucial for proper system operation. ALARMS are cautionary only, and indicates a degradation in a system parameter.

Logging: All fault and alarm events are logged with the date and time.

Alarm screen reset: After viewing the screen, press ENTER to clear all logs entries. If the alarm has been corrected, no new logs will be generated.

FAULTS

Module	Parameter	Nominal	Trip Value	LED Status
QAM RF TX	Forward Power	1.0 Watt	< 0.5 Watt	RADIATE
	AFC Lock	Lock	Unlock	AFC LOCK
	PA Temp	40 deg C	>80 deg C	
QAM RF RX	AFC Lock	Lock	Unlock	AFC LOCK
QAM MODEM	AFC Lock	Lock	Unlock	MOD/DEM LOCK
	Mbaud	Lock	Unlock	MOD/DEM LOCK
	Dbaud	Lock	Unlock	MOD/DEM LOCK
	Dfec	Lock	Unlock	MOD/DEM LOCK

Fault definition: A specific parameter is out of tolerance and is crucial for proper system operation.

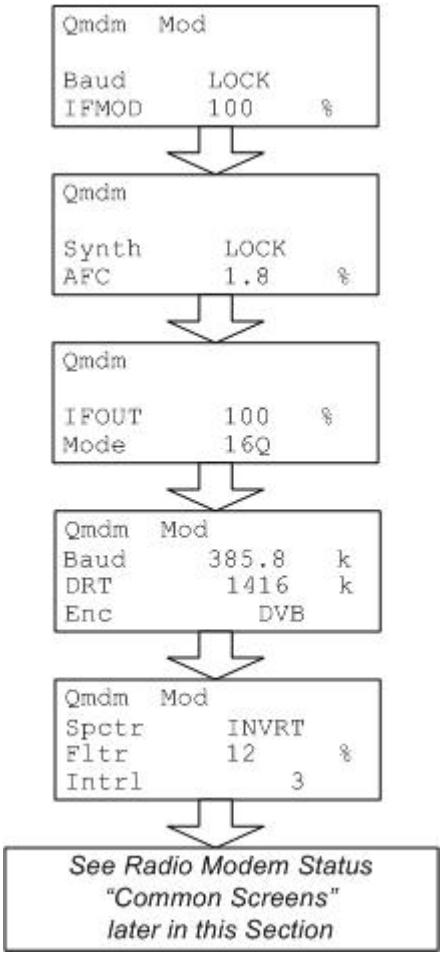
Logging: All fault and alarm events are logged with the date and time.

Fault screen reset: After viewing the screen, press ENTER to clear all logs entries. If the fault has been corrected, no new logs will be generated.

4.4.12 Radio: Modem Status (QAM)

The following sections summarize the Modem Status screens. They are grouped into functional sections (TX, RX, BER), and concludes with the screens that are common to all the functional groupings.

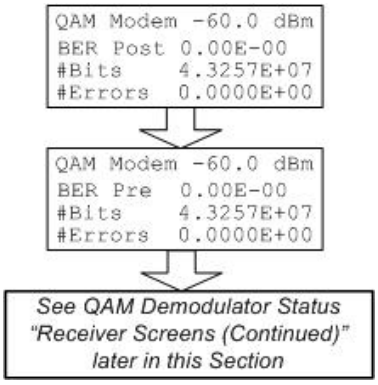
4.4.12.1 QAM Modulator Status - Transmitter



Function	Settings	Summary
BAUD	LOCK (default) UNLOCK	Indicates modulator PLL is locked to incoming data clock
IFMOD	100% NOM	Modulator level
SYNTH	LOCK (default) UNLOCK	Confirms 70 MHz IF synthesizer is phase locked
AFC	1.8 VDC (nominal)	70 MHz IF synthesizer AFC voltage
IFOUT	100% (nominal)	IF output level
Mode	16Q (nominal) 32Q 64Q 128Q 256Q QPSK	Modulation mode
BAUD	xxx.x k	Symbol rate
DRT	xxxx k	Data rate
ENC	DVB	Encoding mode

SPCTR	NRML	Spectrum Normal or Invert
FLTR	xx %	Nyquist filter
INTRL	x	Interleave Depth

4.4.12.2 QAM Demodulator Status - Receiver BER Screens



Function	Settings	Summary
BER Post	0.00E-00	Post-FEC (Forward Error Correction) Bit Error Rate since last “ENTER” reset
BER Pre	0.00E-00	Pre-FEC (Forward Error Correction) Bit Error Rate since last “ENTER” reset
# Bits	0.0000E+00	# of Bits counted since last “ENTER” reset
# Errors	0.0000E+00	# of Errors counted since last “ENTER” reset

Interpreting BER

BER (Bit-Error-Rate or Bit-Error-Ratio) is a useful measure of reception quality, analogous to signal-to-noise ratio used in analog systems. It is the ratio of error bits received to data bits transmitted. This is an averaged value calculated as the total number of uncorrectable received errors (#Errors) divided by the total number of error-free received bits (#Bits) from the time the counters were last reset by pressing <ENTER>.

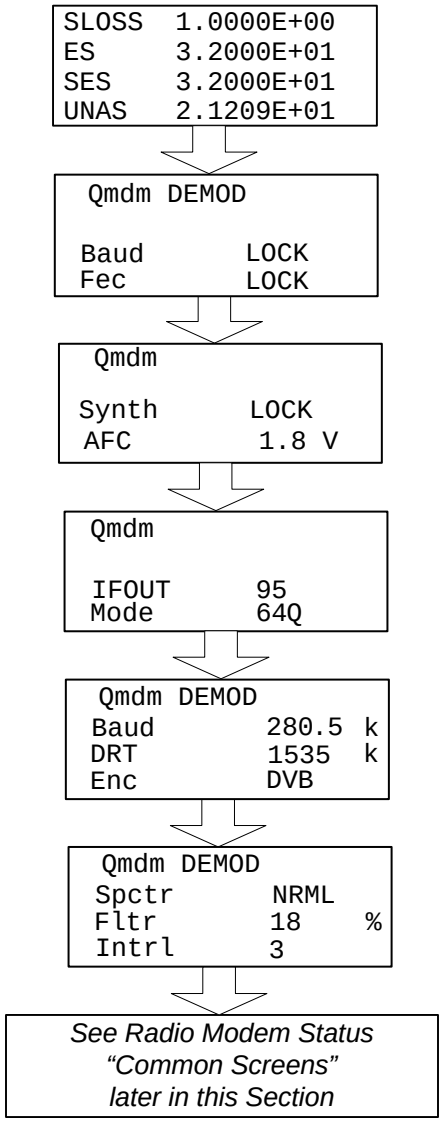
The "Post-BER" provides the error-ratio after error correction has been applied. This is the operational error performance of the radio. An error displayed here is one that the audience may see or hear. Perceptually a listener will not detect single error occurrences at a post error rate of 1e-10, or about one error per hour. Typically a properly aligned link should anticipate error free link performance ("Post-BER" of 0.00E+00) under normal conditions.

The "Pre-BER" provides the error-count before error correction has been applied. This provides a secondary indication for trouble-shooting and alignment purposes. The effects of various impairments normally repaired by error-correction will be seen here. Note: “Pre-BER” may indicate a static (non-zero) error rate under normal operation, depending QAM mode, especially in the higher QAM modes of operation such as 32 QAM and 64 QAM resulting from transmitter power amplifier IMD. This is normal.

To determine the rate at which errors occur, or how many errors occur in any period of time, multiply the BER by the Data Rate and scale by the amount of time. For instance to calculate the average number of errors in an hour period, BER (errors/bit)* Data Rate (bits/sec) * 60 secs/min * 60 min/hour, for example:

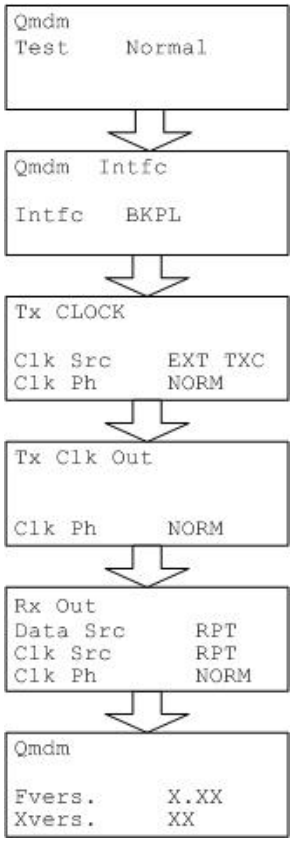
1.46E-10 errs/bit * 2.048E+06 bps* 60 secs/min * 60 min/hour = 1.08 errors/hour

4.4.12.3 QAM Demodulator Status - Receiver Screens (Continued)



Function	Settings	Summary	
SLOSS	x.xxxE+xx	Signal Loss	Used for Evaluating and troubleshooting errors over time. Press ENTER to clear the screen.
ES	x.xxxE+xx	Error Seconds	
SES	x.xxxE+xx	Severely Errored Seconds	
UNAS	x.xxxE+xx	Unavailable Seconds	
BAUD	LOCK (default) UNLOCK	Indicates modulator PLL is locked to incoming data clock	
FEC	LOCK (default) UNLOCK	Indicates FEC decoder is synchronized	
SYNTH	LOCK (default) UNLOCK	Confirms 70 MHz IF synthesizer is phase locked	
AFC	1.8 VDC (nominal)	70 MHz IF synthesizer AFC voltage	
IFOUT	100% NOM	Modulator level	
Mode	16Q (nominal) 32Q 64Q 128Q 256Q QPSK	Modulation mode	
BAUD	xxx.x K	Symbol rate	
DRT	xxxx K	Data rate	
ENC	DVB	Encoding mode	
SPCTR	NRML	Spectrum Normal or Invert	
FLTR	xx %	Nyquist filter	
INTRL	x	Interleave Depth	

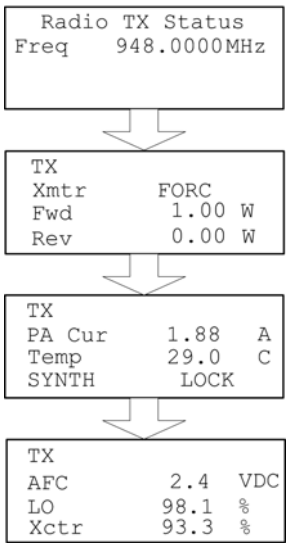
4.4.12.4 Radio Modem Status - Common Screens



Function	Settings	Summary
TEST	NORMAL PRBS15 PRBS23	Internal Test Pattern Generator
INTFC	 BKPL TRNK	Modem Interface: Backplane Trunk connector
TX Clock	Clk Source: EXT TXC EXT RXC RECOVERED INTERNAL Clk Phase: Normal Inverted	 External TX Clock External RX Clock Recovered Clock Internal Clock Normal Inverted
TX Clock Out	Clk Phase: Normal Inverted	 Normal Inverted

RX Clock	DATA Source: RPT CLK Source: RPT Clk Phase: Normal Inverted	
FVers.	x.xx	Firmware Version
Xvers.	xx	IC firmware Version

4.4.13 Radio TX Status



Function	Settings	Summary
Freq A	948.0000 MHz	Displays the transmitter output carrier frequency
XMTR	 TRAFFIC FORCED (default)	Status of transmitter: ON in a hot standby mode Forced ON
FWD	1.00 Watt (nominal)	Output Power of TX
REV	0.07 Watt (nominal)	Reverse (or reflected) power at antenna port
PA CUR	1.8 Amp (nominal)	Power amplifier current consumption
TEMP	29.0 deg C (nominal)	Power amplifier temperature
SYNTH	LOCK (nominal) UNLOCK	Indicates phase lock of the 1st LO
AFC	2.4 VDC (nominal)	1st LO PLL AFC Voltage
LO	100% (nominal)	1st LO relative power level
XCTR	100% (nominal)	Transmit module's relative output power level

Warning on Adjusting Transmit Power

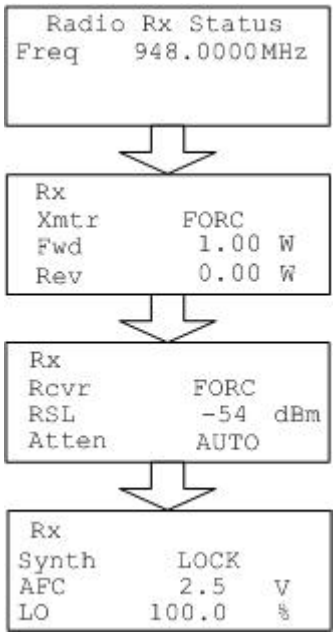
Attempting to increase the transmit power will cause the radio to fail to operate.

Why? The digital QAM modulation used in the SL9003Q though very spectrally efficient is *extremely sensitive* to channel linearity. When shipped from the factory the system is operating at its maximum transmit efficiency.

The transmitter power amplifier consumes the most current so is operated close to its peak output power, 10 Watts (+40 dBm) for highest efficiency. This provides a averaged output power, 1.25 Watts (+31 dBm) and acceptable intermodulation distortion (IMD) for the receiver to effectively equalize. Increasing the transmit power beyond this factory set level will generate increase IMD, and result in data errors at the receiver. The higher order QAM modes are particularly sensitive to IMD.

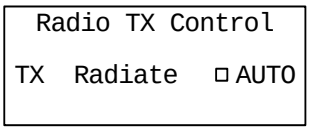
This IMD issue is also raised with the addition of post-amplification or booster amplifier. This amplifier must be a linear Class-A amplifier. Class-C power amplifiers used with analog FM STLs will not work. The post-amplifier compression point should be between 6 dB (16 QAM) and 9 dB (64 QAM) higher than the expected average transmit power.

4.4.14 Radio RX Status



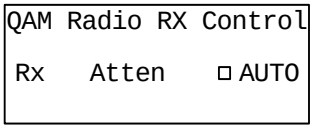
Function	Settings	Summary
Freq	948.0000 MHz	Displays the receiver operating frequency
XMTR	 TRAFFIC FORCED (default)	Transfer status of receiver: Is operating, ready for transfer Is operating, will not transfer (forced ON)
RSL	-30.0 to -90.0 dBm	Received signal level (signal strength) Nominal level dependent upon customer path/system gain
ATTEN	 AUTO (default) ON OFF	Receiver PIN attenuator setting: Controlled by internal software Forced ON Forced Off
SYNTH	LOCK (nominal) UNLOCK	Indicates phase lock of the 1st LO
AFC	2.4 VDC (nominal)	1st LO PLL AFC Voltage
LO	100% (nominal)	1st LO relative power level

4.4.15 Radio TX Control



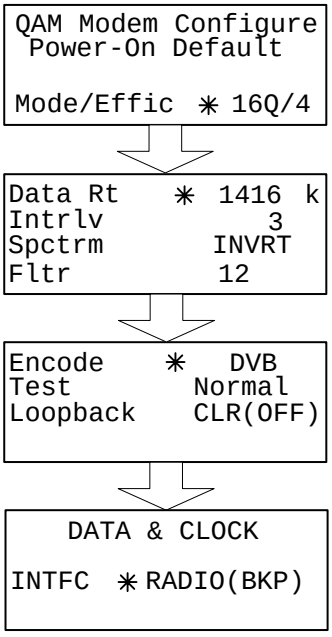
Function	Settings	Summary
TX Radiate	AUTO (default) ON OFF	Transmitter radiating, but folds back output power on high antenna VSWR (REV PWR) Transmitter radiating Transmitter not radiating

4.4.16 Radio RX Control



Function	Settings	Summary
RX ATTEN	AUTO (default) ON OFF	ON, and is activated on high signal level ON always OFF

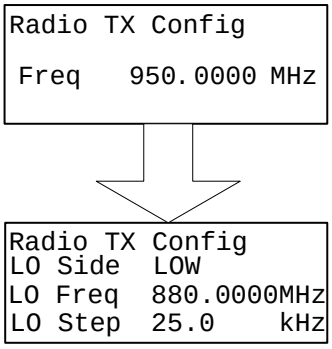
4.4.17 Radio Modem (QAM) Configure



Function	Settings	Summary
Mode/Effic	16Q/4 32Q/5 64Q/6 128Q/7 256Q/8 QPSK/2	Select Modulation mode
DATA RATE	N x 64 kbps, 2048	Valid range depends upon configuration.
INTERLEAVE	1,204 2,102 3, 68 (default) 4,51 6,34 12,17 17,12 34,6 51,4 68,3 102,2 204,1	Interleave depth. 1 to 204 valid for full duplex modem only “ “ “ “ “
SPECTRUM	NORMAL (default) INVERT	
FILTER	---- 18 15 (default) 12	Nyquist roll-off factor
ENCODING	DVB (default) DAVIC, BRCM, NO FEC	Raw data format
TEST	NORMAL (default) PBRS15, PBRS15M, PBRS23, PBRS23M	Test pattern length
Loopback	CLR(OFF) RMT & LOC RPTR	Data Flow Configuration for repeater and test purposes
DATA & CLOCK	INTERFACE: RADIO(BKP) CUSTOM(Trunk) DTE(Trunk) DCE(Trunk)	 Backplane/Auto-Setup (uses bus) Trunk connector; (custom-user settings) Trunk connector DTE (presets) Trunk connector DCE (presets)
The following screens are only available for custom trunk settings:		

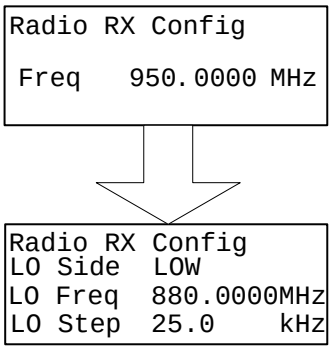
TX Clock	Clk Source: EXT TXC EXT RXC RECOVERED INTERNAL Clk Phase: Normal Inverted	 External TX Clock External RX Clock Recovered Clock Internal Clock Normal Inverted
TX Clock Out	Clk Phase: Normal Inverted	 Normal Inverted
RX Clock	Clk Source: EXT TXC EXT RXC RECOVERED INTERNAL Clk Phase: Normal Inverted	 External TX Clock External RX Clock Recovered Clock Internal Clock Normal Inverted

4.4.18 Radio TX Configure



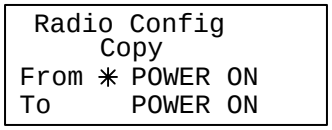
Function	Settings	Summary
FREQ	950.5000 MHz	Displays the frequency of the transmitter and allows the user to make frequency changes.
LO Side	Low/High	User Lockout
LO Freq	880.0000 MHz	Depends on LO Side and Customer Freq.
LO Step	25.0 kHz (std)	Oscillator step size

4.4.19 Radio RX Configure



Function	Settings	Summary
FREQ	950.5000 MHz	Displays the frequency of the receiver and allows the user to make frequency changes.

4.4.20 Radio Modem/TX/RX Copy Function



Function	Settings	Summary
Copy From	Power On Factory 1	This "images" the factory setup, and allows the user to do a complete restore to original shipped configuration. Please contact Customer Service for details

4.5 Intelligent Multiplexer PC Interface Software

The Intelligent Multiplexer is configured with a Windows-based PC software package. The hardware is accessed through the parallel port on the MUX back panel. A separate manual is available for operational details of this interface.

4.6 NMS/CPU PC Interface Software

The NMS/CPU card is configured with a Windows-based PC software package. The hardware is accessed through the serial port on the NMS card back panel. A separate manual is available for operational details of this interface.

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5 Module Configuration

5.1 Introduction

This section provides the experienced user with detailed information concerning the board level switches, jumpers and test points that may be necessary for configuring or troubleshooting modules in the SL9003Q.

This information is provided for advanced users only, or can be used in conjunction with a call to our Technical Services personnel. Changing of these settings may render the system unusable, proceed with caution!

5.2 Audio Encoder/Decoder

The Audio Encoder accepts digital or analog audio. A/D conversion is performed for the analog inputs. The stereo digital audio is encoded for linear (or MPEG) operation. The resultant data stream is applied to the QAM modulator or MUX. An auxiliary data channel is available.

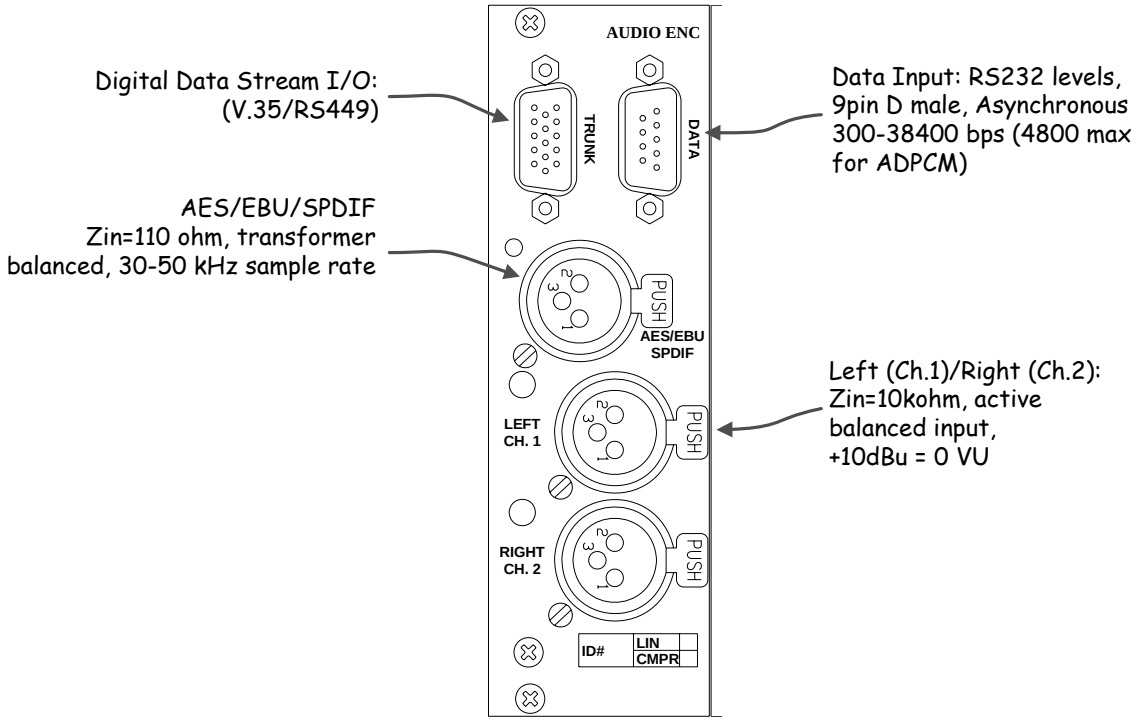

Figure 5-1 Audio Encoder Front Panel

The Audio Decoder accepts the data streams from the QAM demodulator or MUX. The data is decoded for linear (or MPEG) stereo digital audio output. D/A conversion is performed for the analog outputs. An auxiliary data channel is available.

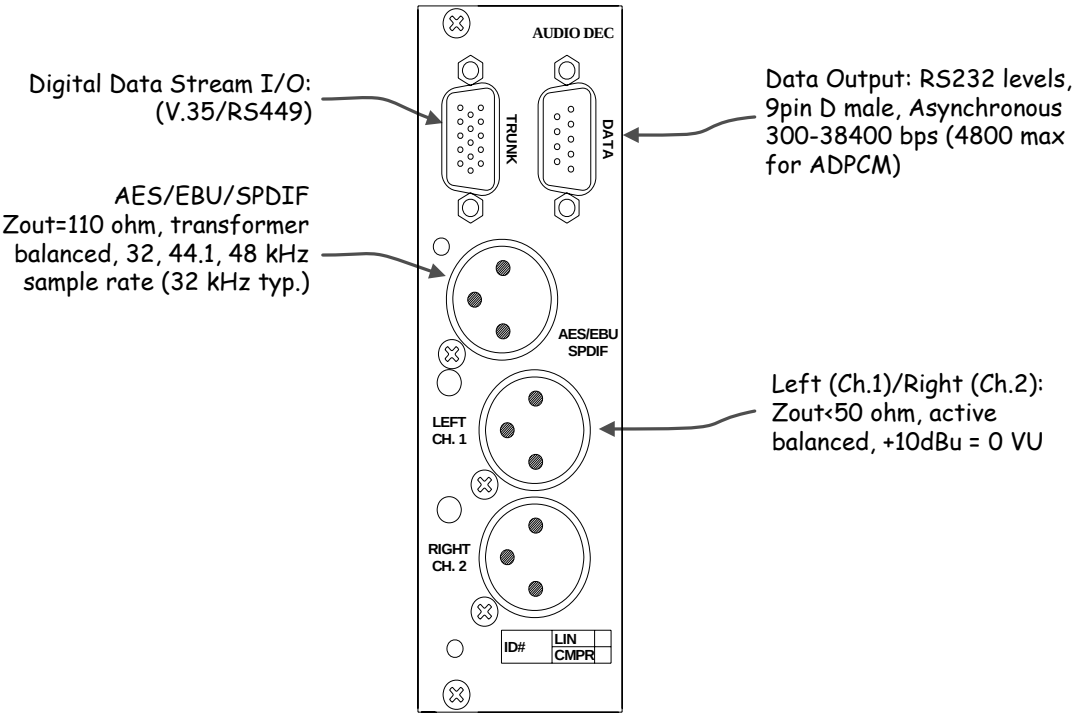

Figure 5-2 Audio Decoder Front Panel

Switch and jumper settings for the Audio Encoder and Audio Decoder are shown in Figures 5-1 and 5-2, respectively. The following sections will clarify the particular groupings of switches.

CAUTION:

Avoid excessive pressure on the audio adjustment potentiometers located on the back panels of the Audio Encoder/Decoder modules.

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MPEG Encoder-M

M1	M0	ISO/MPEG Coding mode
off=0	off=0	mono
off=0	on=1	dual channel /double mono (C5)
on=1	off=0	joint stereo [default]
on=1	on=1	stereo

M5	M4	M3	M2	Output Rate
off=0	off=0	off=0	off=0	reserved
off=0	off=0	off=0	on=1	32 kb/s
off=0	off=0	on=1	off=0	48 kb/s
off=0	off=0	on=1	on=1	56 kb/s
off=0	on=1	off=0	off=0	64 kb/s
off=0	on=1	off=0	on=1	80 kb/s
off=0	on=1	on=1	off=0	96 kb/s
off=0	on=1	on=1	on=1	112 kb/s
on=1	off=0	off=0	off=0	128 kb/s
on=1	off=0	off=0	on=1	160 kb/s
on=1	off=0	on=1	off=0	192 kb/s
on=1	off=0	on=1	on=1	224 kb/s
on=1	on=1	off=0	off=0	256 kb/s [default]
on=1	on=1	off=0	on=1	320 kb/s
on=1	on=1	on=1	off=0	384 kb/s
on=1	on=1	on=1	on=1	forbidden

M7	M6	
0	0	reserved

S81 – AES/EBU

S81-A	S81-B	S81-C	S81-D	S81-E	AES/EBU/SPDIF
off	on	off	off	on	AES/EBU (default)
on	on	off	off	off	SPDIF

S81-VERF	S81-ERF	AES/EBU VERF/ERF
on	off	Validity Bit & Error Flag
off	on	Error Flag Only (default)

S81-8	Reserved
off=0	reserved

Audio In Card

E2-E5	Analog Input Impedance
600	600 ohms
HI-Z	>10kohms (default)

E3-E6	dB Gain	Nominal Input Level
0	0 (default)	+10 dBu (default)
6	6	+4 dBu
20	20	-10 dBu
40	40	-30 dBu

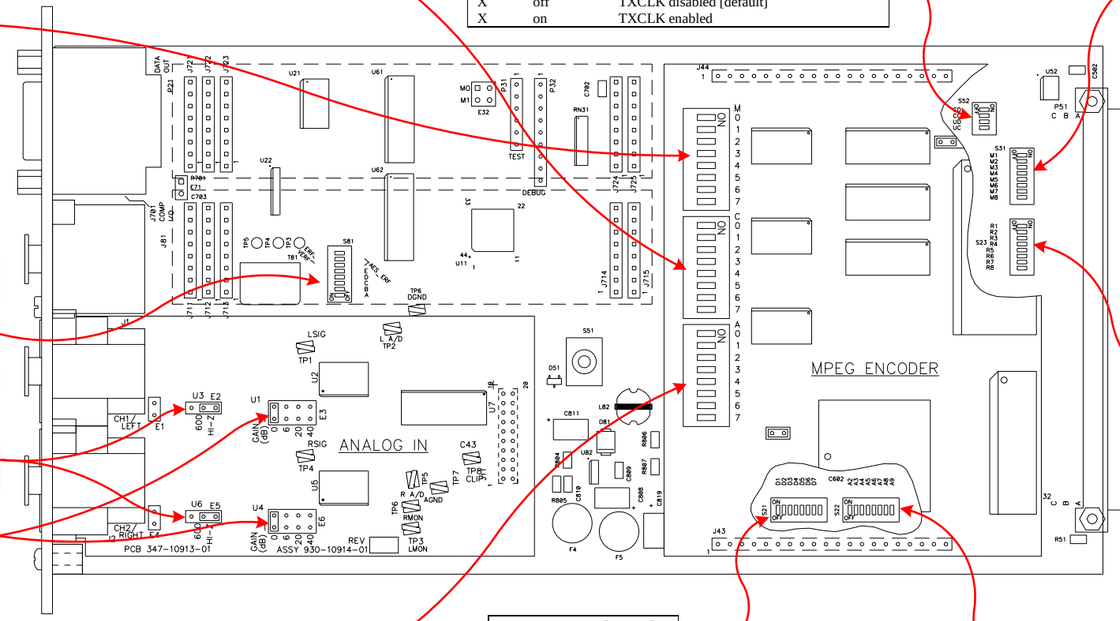
MPEG Encoder - C

C5	Coding Mode
off=0	dual channel [default]
on=1	double mono

S52 – System Clock

TXD	TXC	Modem TX Compressed
off	X	TXDATA disabled [default]
on	X	TXDATA enabled
X	off	TXCLK disabled [default]
X	on	TXCLK enabled

S52-3	S52-4	Modem TX Linear
off	X	TXDATA disabled [default]
on	X	TXDATA enabled
X	off	TXCLK disabled [default]
X	on	TXCLK enabled



S31 – System Config

M1	M2	Input Rate (A/D & AES/EBU/SPDIF &SRC
off=0	off=0	44.1 kHz (internal osc)
off=0	on=1	48.0 kHz (internal osc)
on=1	off=0	32.0 kHz (internal osc) [default]
on=1	on=1	AES/EBU (variable from AES/EBU/SPDIF)

M3	AES/EBU/SPDIF mode
off=0	AES=master A/D=secondary [default]
on=1	No input switching (M1, M2=source)

M4	M5	M6	VCO Clock Source	Bus Clock
off=0	off=0	off=0	input mode (M1,M2)	ignore
off=0	off=0	on=1	internal oscillator	ignore
off=0	on=1	off=0	trunk compressed	ignore
off=0	on=1	on=1	trunk linear	ignore
on=1	off=0	off=0	reserved	input
on=1	off=0	on=1	reserved	input
on=1	on=1	off=0	mux compressed	input
on=1	on=1	on=1	mux linear	input

M7	M8	Linear Data Rate
off=0	off=0	44.1 kHz
off=0	on=1	48.0 kHz
on=1	off=0	32.0 kHz [default]
on=1	on=1	44.0 kHz

S23 – System Config

R1	R2	Sample Rate Converter Data Source
off=0	off=0	AES/EBU/SPDIF [default]
off=0	on=1	A/D Converter
on=1	off=0	Zeros (gnd)
on=1	on=1	Sine Generator

R3	Bus Master Clock
off=0	receive clock from mux bus [default]
on=1	supply clock to mux bus

R4	Aux RS-232 Data
off=0	Disabled
on=1	Enabled [default]

R5	R6	2- /4 – Channel Select
off=0	off=0	2-Channel
off=0	on=1	reserved
on=1	off=0	4-Channel Master (1st pair)
on=1	on=1	4-Channel Slave (2nd pair)

R7	9003 LEDs & Metering
off=0	Disabled /FP Select [default]
on=1	Enabled / Forced On

R8	Debug
off=0	Normal [default]
on=1	Debug (B-bus = outputs)

MPEG-Encoder A

A7	A6	ISO/MPEG Input Rate
off=0	off=0	44.1 kHz
off=0	on=1	48.0 kHz (default)
on=1	off=0	32 kHz
on=1	on=1	reserved

A5	A4	A3
0	0	0 reserved

A2	A1	A0
0	0	0 reserved

S21 – Data Channel

D1	D2	Aux Data # of Bits
off=0	off=0	6 (6N/5E/50)
off=0	on=1	7 (7N/6E/60)
on=1	off=0	8 (8N/7E/70) [default]
on=1	on=1	9 (9N/8E/80)

D3	D4	D5	Aux Date Rate
off=0	off=0	off=0	300
off=0	off=0	on=1	600
off=0	on=1	off=0	1200 [default]
off=0	on=1	on=1	2400
on=1	off=0	off=0	4800
on=1	off=0	on=1	9600 +
on=1	on=1	off=0	19200 +
on=1	on=1	on=1	38400 +

+ MUST use CTS Line

D6	Reserved
off=0	Reserved [default]
on-1	Reserved

D7	Test
off=0	Disabled [default]
on=1	Enabled

D8	Debug
off=0	Normal [default]
on=1	Enabled

S22 – Board ID

A2	A3	A4	A5	A6	A7	A8	A9	Board #	Base Addr
off	off	off	off	off	off	off	off	0	0
off	on	off	off	off	off	off	off	2	8
off	off	on	off	off	off	off	off	3	16
off	off	off	on	off	off	off	off	4	32
off	off	off	off	off	on	off	off	6	128
off	off	off	off	off	off	on	off	7	256

Figure 5-3 Audio Encoder PC Board / Switch & Jumper Settings

ISO/MPEG Decoder Board

M1	M2	M3	M4	ISO/MPEG Rate
off=0	off=0	off=0	off=0	reserved
off=0	off=0	off=0	on=1	32 kb/s
off=0	off=0	on=1	off=0	48 kb/s
off=0	off=0	on=1	on=1	56 kb/s
off=0	on=1	off=0	off=0	64 kb/s
off=0	on=1	off=0	on=1	80 kb/s
off=0	on=1	on=1	off=0	96 kb/s
off=0	on=1	on=1	on=1	112 kb/s
on=1	off=0	off=0	off=0	128 kb/s
on=1	off=0	off=0	on=1	160 kb/s
on=1	off=0	on=1	off=0	192 kb/s
on=1	off=0	on=1	on=1	224 kb/s
on=1	on=1	off=0	off=0	256 kb/s
on=1	on=1	off=0	on=1	320 kb/s
on=1	on=1	on=1	off=0	384 kb/s
on=1	on=1	on=1	on=1	forbidden

S52 – System Clock

RXD	RXC	Modem RX Compressed
off	X	RXDATA disabled [default]
on	X	RXDATA enabled
X	off	RXCLK disabled [default]
X	on	RXCLK enabled

S52-3	S52-4	Modem RX Linear
off	X	RXDATA disabled [default]
on	X	RXDATA enabled
X	off	RXCLK disabled [default]
X	on	RXCLK enabled

S32 – System Config

M1	M2	Input Rate (A/D & AES/EBU/SPDIF &SRC
off=0	off=0	44.1 kHz (internal osc)
off=0	on=1	48.0 kHz (internal osc)
on=1	off=0	32.0 kHz (internal osc) [default]
on=1	on=1	Linear Rate (M7, M8)

M3	VCO Test
off=0	Normal (external)
on=1	Test (internal)

M4	FIFO data source
off=0	trunk
on=1	mux

M5	M6	VCO Source
off=0	off=0	trunk compresssed
off=0	on=1	trunk linear
on=1	off=0	mux compressed
on=1	on=1	mux linear

M7	M8	VCO Rate	Clk Freq
off=0	off=0	44.1 kHz	11.286 MHz
off=0	on=1	48.0 kHz	12.2880 MHz
on=1	off=0	32.0 kHz	8.1920 MHz
on=1	on=1	44.0 kHz	11.2460 MHz

S23 – System Config

R1	R2	Sample Rate Cnvtr Data Source
off=0	off=0	Compressed
off=0	on=1	Linear
on=1	off=0	Zeros (gnd)
on=1	on=1	Sine

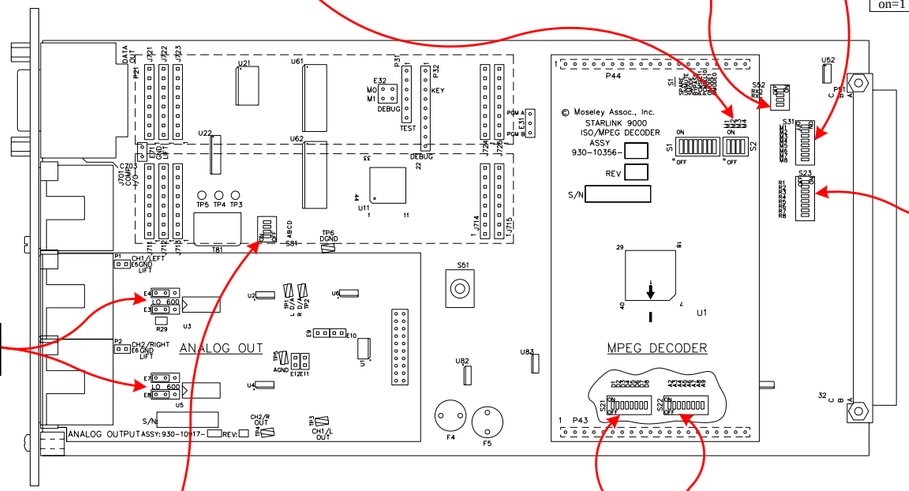
R3	Trunk Compressed Input Clock
off=0	Normal [default]
on=1	Inverted

R4	Trunk Linear Input Clock
off=0	Normal [default]
on=1	Inverted

R5	R6	2-/4-Channel Select
off=0	off=0	2-Channel
off=0	on=1	reserved
on=1	off=0	4-Channel Master (1st pair)
on=1	on=1	4-Channel Slave (2nd pair)

R7	9003 LEDs & Metering
off=0	Disabled/FP Select [default]
on=1	Enabled/Forced On

R8	Debug (B-Bus)
off=0	disabled [default]
on=1	enabled



Audio Out Card

E3-E4-E7-E8	Analog Output Impedence
LO	<5 ohms
600	600 ohms [default]

S81- AES/EBU

S81-A	S81-B	S81-c	S81-D	S81-E	AES/EBU/SPDIF
off	off	off	off	on	AES/EBU [default]
on	on	off	off	off	SPDIF

S21 – Data Channel

D1	D2	Aux Data # of Bits
off=0	off=0	6 (6N/5E/50)
off=0	on=1	7 (7N/6E/60)
on=1	off=0	8 (8N/7E/70) [default]
on=1	on=1	9 (9N/8E/80)

D3	D4	D5	Aux Date Rate
off=0	off=0	off=0	300
off=0	off=0	on=1	600
off=0	on=1	off=0	1200 [default]
off=0	on=1	on=1	2400
on=1	off=0	off=0	4800
on=1	off=0	on=1	9600 +
on=1	on=1	off=0	19200 +
on=1	on=1	on=1	38400 +

+ MUST use CTS Line

D6	Reserved
off=0	Reserved [default]
on-1	Reserved

D7	Test
off=0	Disabled [default]
on=1	Enabled

D8	Debug
off=0	Normal [default]
on=1	Enabled

S22 – Board ID

A2	A3	A4	A5	A6	A7	A8	A9	Board #	Base Addr
off	off	off	off	off	off	off	off	0	0
off	on	off	off	off	off	off	off	2	8
off	off	on	off	off	off	off	off	3	16
off	off	off	on	off	off	off	off	4	32
off	off	off	off	off	on	off	off	6	128
off	off	off	off	off	off	on	off	7	256

Figure 5-4 Audio Decoder PC Board / Switch & Jumper Settings

5.2.1. AES/EBU and SPDIF

Switch S81 configures the digital audio input (Encoder) or output (Decoder) for the AES/EBU “professional” standard (3 wire XLR balanced) or SPDIF “consumer” standard (2 wire unbalanced). The AES/EBU setting is the factory default. The following wiring shown in Figures 5-5 through 5-8 should be followed for the proper level and phasing:

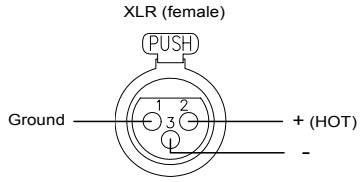


Figure 5-5 AES/EBU-XLR Encoder Connection

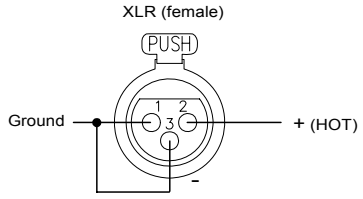


Figure 5-6 SPDIF-XLR Encoder Connection

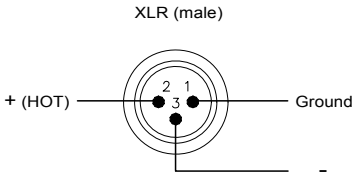


Figure 5-7 AES/EBU-XLR Decoder Connection

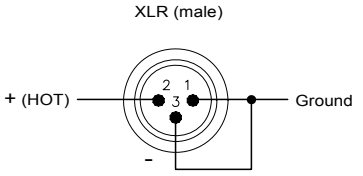


Figure 5-8 SPDIF-XLR Decoder Connection

5.2.2. Analog Audio Gain and Input Impedance

Encoder (Analog In Card):
Jumpers E2 and E5 set the left and right channel input impedance. HI-Z is default (shown) and the user may set it to 600 ohm for external equipment compatibility.

Jumpers E3 and E6 set the gain for the analog input stage. 0 dB is default (shown) and the user may set the unit for up to 40 dB of additional gain if the external equipment has a low output level.

Decoder (Analog Out Card):
Jumpers E3/E4 and E7/E8 set the left and right channel output impedance. LO-Z is default (shown) and the user may set it to 600 ohm for external equipment compatibility.

5.2.3. Data Channel Rate

Switch S21 sets up the data channel parameters for the card. Follow the charts in the figure for details of the settings. Figure 5-9 below details the serial data connection:

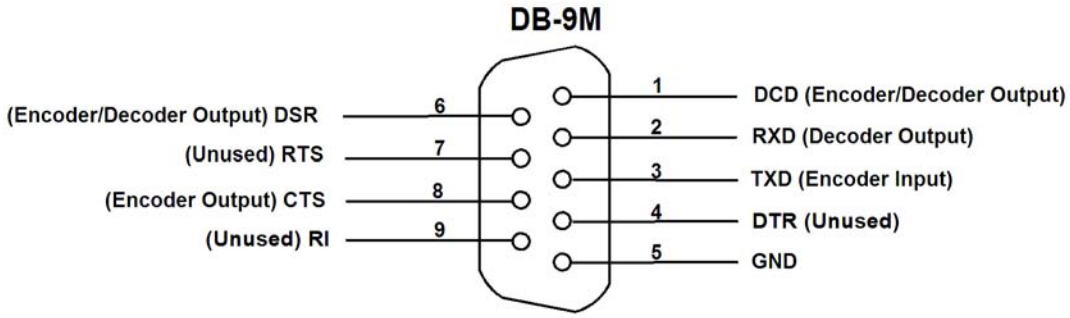


Figure 5-9 Data Channel Connector- DSUB (9-pin)

5.2.4. Board ID

Switch S22 sets the Board ID number and Base Address. These are not to be changed by the user.

5.2.5. System Configuration

Switches S23, S31, and S52 set the board configuration for operation in the system. These are not to be changed by the user.

5.3 Digital Composite System

5.3.1. Data Channel

Figure 5-10 shows a typical interconnection of remote control (Burk ARC-16) and corresponding settings on the composite card for proper operation. Default data interface is RS-232 300 baud, 8 bit, odd parity. Note: The cable assemblies for both transmit and receive side are the same. The jumpers in position E100 on the composite card are changed for proper data flow.
Other cable configurations may be used, but may require changing the jumper positions as required. For typical null modem RS-232 cables, set E100 in vertical position.

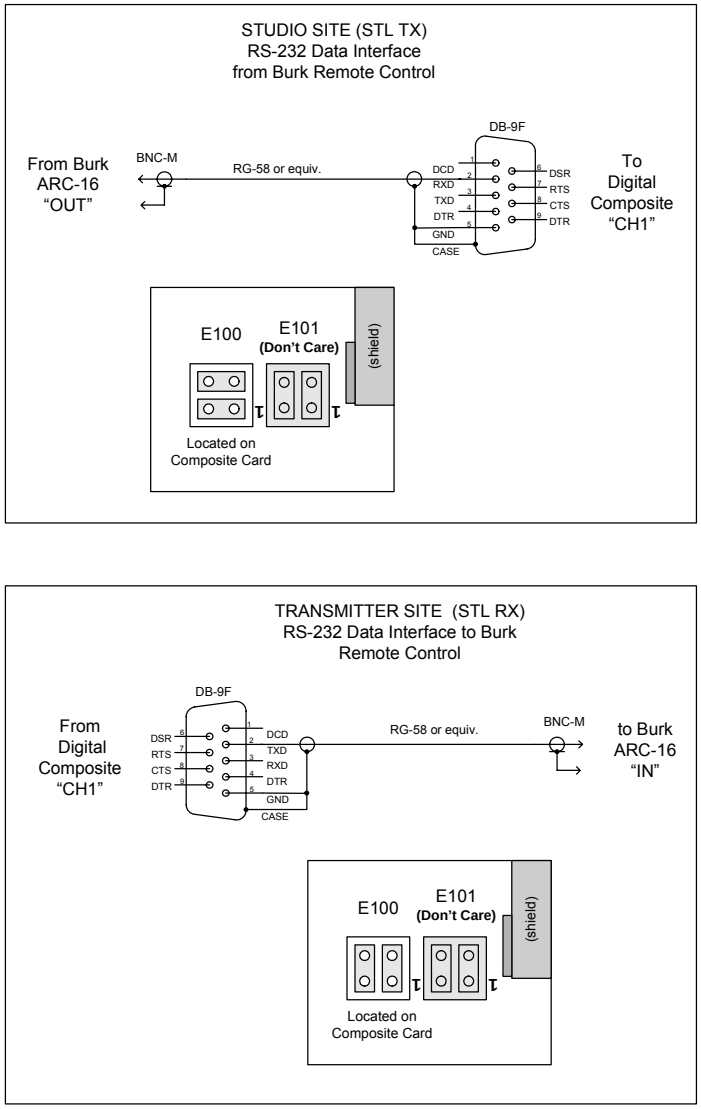


Figure 5-10 Burk Remote Control Interconnection with Auxiliary Data Channel

5.4 QAM Modulator/Demodulator

There are no user adjustments on this card. All calibrations are factory-set, and configuration settings are controlled remotely by software (via the front panel or serial port).

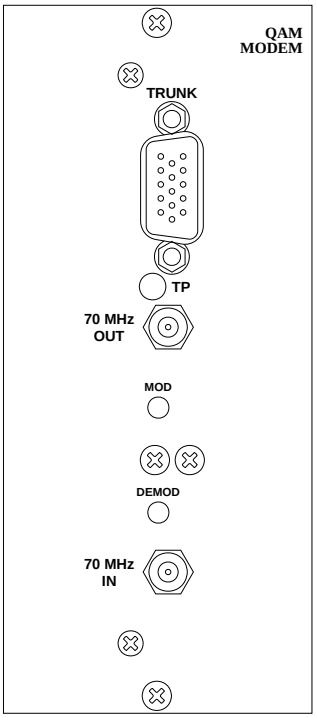


Figure 5-11 QAM Modem Front Panel

5.5 IF Card Upconverter/Downconverter

There are no user adjustments on this card. All calibrations are factory-set, and configuration settings are controlled remotely by software (via the front panel or serial port).

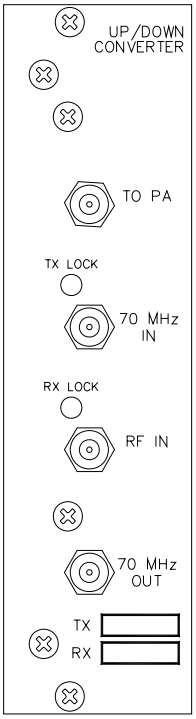


Figure 5-12 Up/Down Converter Front Panel

5.6 Transmit/Receiver Module (RF Up/Downconverter)

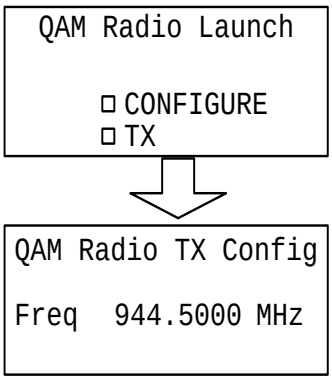
There are no user adjustments on this card. All calibrations are factory-set, and configuration settings are controlled remotely by software (via the front panel or serial port).

5.6.1. Changing Frequency — TX

The carrier frequency of the transmitter may be changed via the front panel within a 20 MHz range without internal adjustment or realignment.

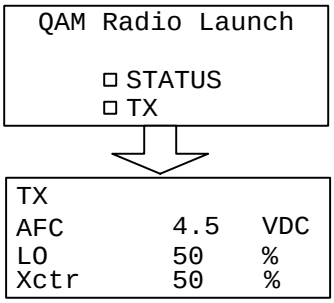
This is accomplished as follows:

1. Power-up the unit and navigate the LCD screens as follows and press enter:



2. Using the cursors, change to the desired frequency. Press ENTER. The unit should continue to indicate AFC LOCk (green) on the front-panel.

3. The transmitter synthesizer AFC voltage will change depending on the frequency programmed from the front panel. This voltage will typically be between 0.5 Vdc to 8.5 Vdc for the 944 MHz to 952 MHz band. Navigate the LCD screens to monitor the AFC voltage as follows:



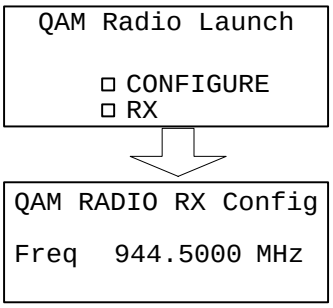
Note: Earlier generations of the SL9003Q required an internal adjustment on the Transmit Module to center the AFC voltage. These units can be identified by a changing of the frequency by 5 MHz will cause the TX AFC to loose lock. With these units the Transmit Module was placed on an extender card to access the TX AFC adjustment. Depending on the "direction" that the frequency was moved, the voltage might read either 0.00 or 9.99 VDC. While monitoring this voltage, the user would adjust the TX AFC on the Transmit Module (using a very small flat blade screwdriver) until the voltage read 4.5 +/- .25 VDC.

5.6.2. Changing Frequency — RX

The carrier frequency of receiver may be changed via the front panel within a 20 MHz range without internal adjustment or realignment.

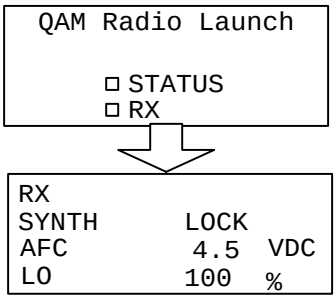
This is accomplished as follows:

1. Power-up the unit and navigate the LCD screens as follows and press enter:



2. Using the cursors, change to the desired frequency. Press ENTER. The unit should continue to indicate AFC LOCK (green) on the front-panel.

3. The receiver synthesizer AFC voltage will change depending on the frequency programmed from the front panel. This voltage will typically be between 1.0 Vdc to 2.4 Vdc for the 944 MHz to 952 MHz band. Navigate the LCD screens to monitor the AFC voltage as follows:



Note: Earlier generations of the SL9003Q required an internal adjustment on the Receiver Module to center the AFC voltage. These units can be identified when changing the frequency by 5 MHz will cause the RX AFC to loose lock. With these units the Receiver Module was placed on an extender card and to access the RX AFC adjustment. Depending on the "direction" that the frequency was moved, the voltage might read either 0.00 or 9.99 VDC. While monitoring this voltage, the user would adjust the RX AFC on the Receive Module (using a very small flat blade screwdriver) until the voltage read 4.5 +/- .25 VDC.

5.6.3. Measuring Carrier Frequency — TX

Typically it will not be necessary to measure the transmit carrier frequency. Starlink transmit carrier is derived from a very stable 0.1 ppm OCXO (ovenized controlled crystal oscillator) and is factory calibrated to an ovenized frequency reference.

However if it is required to measure the carrier frequency this may be achieved by entering the factory calibration menu tree. Here is how:

1. Connect a 30 dB, 5 Watt or greater RF attenuator to the transmitter output.

2. Connect a frequency counter capable of 0.1ppm or better accuracy at 1 GHz to the rf attenuator.

3. Connect AC power to the SL9003Q transmitter unit.

4. Following the “Factory Calibration” menu tree of 4.2C, navigate to the “QAM Modem”, and enter the “OCXO” screen. Enable “CW Mode” to “ON”. This will disable modulation on the carrier so that the carrier frequency may now be measured.

5. Measure the frequency. Set the “CW Mode” to “OFF”.

5.7 Power Amplifier

There are no user adjustments on this module.

5.8 MUX Module

5.8.1. Composite MUX (4-Port)

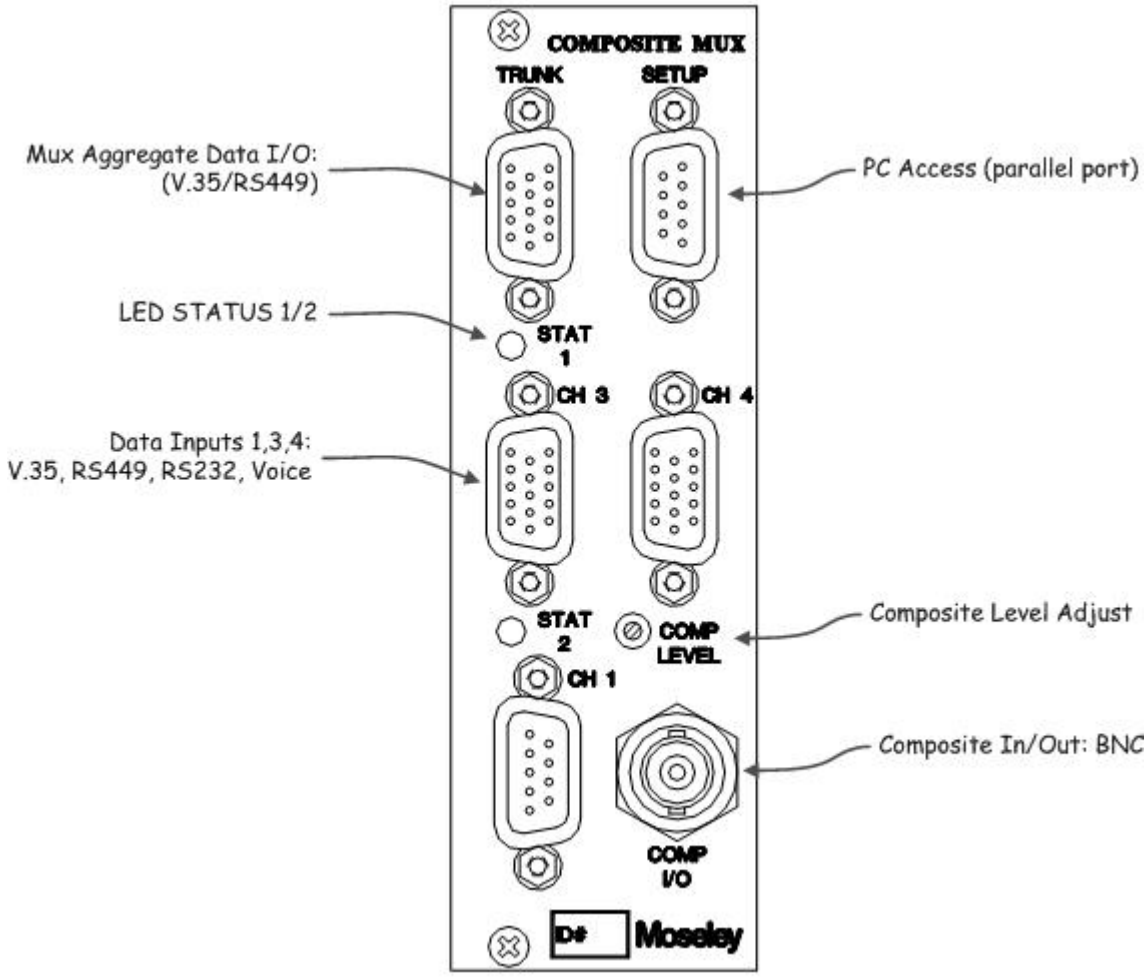


Figure 5-13 Composite MUX (4-Port) Front Panel

The MUX is documented in a separate user manual. Typical broadcast applications are described here:

4-Port Mux:

For composite STL systems, the 4-port mux (with composite option card) is used to route and multiplex the composite signal to the QAM modulator.

5.8.2. 6-Port MUX (Ethernet/IP Interface)

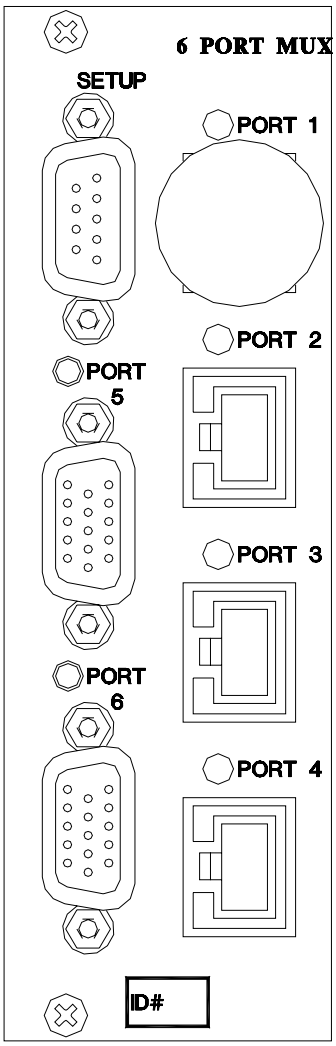


Figure 5-14 6-Port MUX Front Panel

The MUX is documented in a separate user manual. Typical broadcast applications are described here:

6-Port Mux:

For discrete STL systems, the 6-port mux (with Ethernet option card) is primarily used to interface and multiplex an Ethernet data stream for transmission as a data channel.

5.9 NMS/CPU Module

Provides system CPU control, front panel interface & card setup programming.

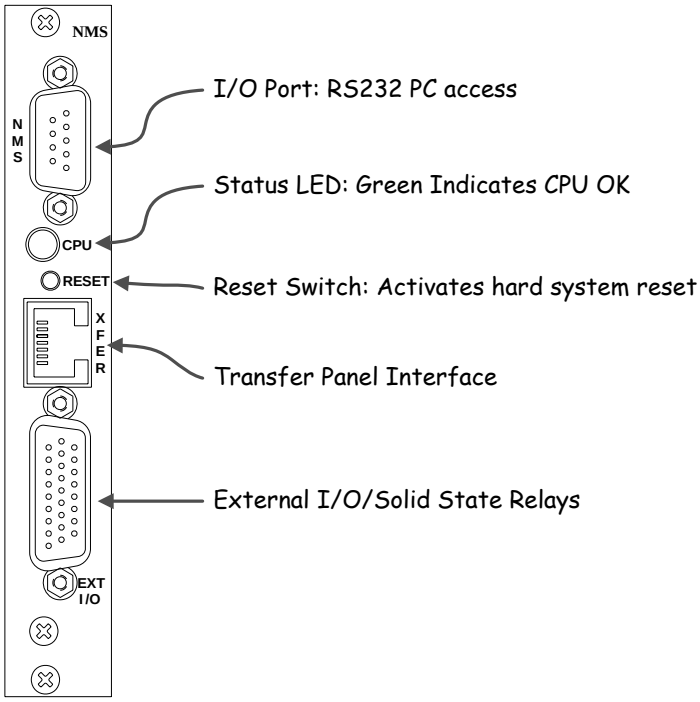


Figure 5-15 SL9003Q NMS Card

5.9.1. External I/O

The NMS External I/O provides control and monitoring via the 26 pin high-density connector on the NMS card. Starting with Firmware Version 3.03 the telemetry and faults may be mapped to specific I/O pins.

This NMS provides remote metering for:

- Transmitter forward and reflected power
- Receiver signal level and BER

and logic outputs for:

- Transmitter control (standby) and transmitter fault
- Receiver signal less than 100dB, receiver fault and High BER

Remote monitoring allows the user to connect external monitoring equipment (i.e., a voltmeter or remote control) to assist in maintenance and logging tasks. Monitoring

received signal level with a voltmeter helps facilitate antenna alignment. Long-term link and path statistics are obtained by logging RSL fade and BER data.

Fig. 5-16 presents the physical pin number locations of the external I/O 26 pin connector. Table 5-1 gives pin descriptions for the 26 pin external I/O interface.

Table 5-1 NMS External I/O Pin Descriptions

Pin	Function	Pin	Function
1	Relay #4 (-)	**14**	Input – Analog #1
2	Relay #4 (+)	**15**	Input – Logic #4
3	Relay#3 (-)	**16**	Input – Logic #3
4	Relay #3 (+)	**17**	Input – Logic #2
5	Relay #2 (-)	**18**	Input – Logic #1
6	Relay #2 (+)	**19**	Ground - Analog
7	Relay #1 (-)	**20**	Ground - Analog
8	Relay #1 (+)	**21**	Ground - Analog
9	Not connected	**22**	Ground - Analog
10	Monitor Out: Rx:RSL 0-5 Vdc Tx:Fwd Pwr 0-5 Vdc	**23**	Ground - Analog
11	Input – Analog #4	**24**	Ground - Digital
12	Input – Analog #3	**25**	+12 Vdc Digital Supply
13	Input – Analog #2	**26**	+5 Vdc Digital Supply

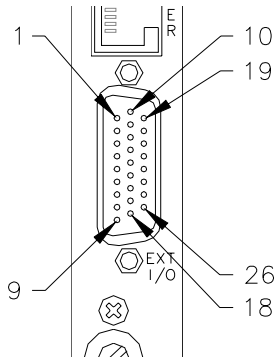


Figure 5-16 NMS Card External I/O Pinout

5.9.2. Relay Electrical Interface

Relays 1 to 4 (pins 8 through 1 on I/O connector, respectively) are solid-state relays rather than mechanical relays. Figure 5-17 below shows a schematic illustration of representative relay interface.

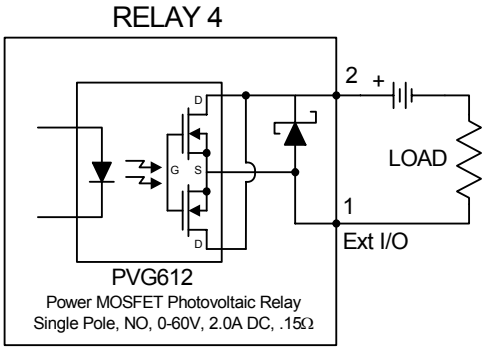


Figure 5-17 Representative Internal Relay Wiring

These relays are International Rectifier PVG612 series HEXFET Power MOSFET Photovoltaic Relay, single-pole, normally-open. Interface parameters are given below:

Max. Voltage	60V
Max Current	2.0A
Open Resistance	100 MΩ
Closed Resistance	0.15 Ω

5.9.3. Relay Mapping Configuration

5.9.3.1. Mapping Set 1 and "Map Faults-Relays" Set ON

The analog output is selected by connecting pins 17 and 18 to ground pins 19-23 in the order shown below:

Analog Output:
Ext I/O pin 10

Digital Input
(external I/O connector):

#18	#17	OUTPUT
Open	Open	BER
Ground	Open	RSL
Open	Ground	FWD PWR
Ground	Ground	REV PWR

To set the mapping, perform the following steps (refer to section 4.4.10 for corresponding menu screens):

On the SL9003Q `Tx Main Menu`
Use Up or Down arrow to select `System`
`<Enter>`
Scroll down to `Unit-Wide Parameters`
`<Enter>`
Scroll up once then down twice to select `Mapping`
`<Enter>`
Use left or right arrow to select setting 0, 1 or 2
`<Enter>`
`<Escape>`
`<Escape>`
Use left or right arrow to select Yes to save settings
`<Enter>`

To set “Map Faults-Relays”, perform the following steps:

On the SL9003Q Tx Main Menu
Use Up or Down arrow to select System
<Enter>
Scroll down to External I/O
<Enter>
Scroll down to Map Fault-Relays
<Enter>
Use left or right arrow to select Off or On for Map to Relays
<Enter>
<Escape>
<Escape>
Use left or right arrow to select Yes to save settings
<Enter>

In a Receiver

Relay 2 pins 5 (-) and 6 (+)

Any Fault or Alarm or Equipment Power Off
Relay 2 = Off (Set Open)

No Faults or Alarms and Equipment Power On
Relay 2 = On (Set Closed)

Relay 3 pins 3 (-) and 4 (+)

Receive RSL < -100dBm or Equipment Power Off
Relay 3 = Off (Set Open)

Receive RSL > -100dBm and Equipment Power On
Relay 3 = On (Set Closed)

Relay 4 pins 1 (-) and 2 (+)

Pre-BER > 1E-4 or Equipment Power Off
Relay 4 = Off (Set Open)

Pre-BER < 1E-4 and Equipment Power On
Relay 4 = On (Set Closed)

In a Transmitter

Relay 1 pins 7 (-) and 8 (+)
Tx control set OFF or transfer set COLD and unit is not Selected or Equipment Power Off
Relay 1 = Off (Set Open)

Tx control set ON or AUTO or transfer set COLD and unit is selected and Equipment Power On
Relay 1 = On (Set Closed)

Relay 2 pins 5 (-) and 6 (+)
Any Fault or Alarm or Equipment Power Off
Relay 2 = Off (Set Open)

No Faults or Alarms and Equipment Power On
Relay 2 = On (Set Closed)

In a Transceiver

Relay 1 pins 7 (-) and 8 (+)
Tx control set OFF or transfer set COLD and unit is not Selected or Equipment Power Off
Relay 1 = Off (Set Open)

Tx control set ON or AUTO or transfer set COLD and unit is selected and Equipment Power On
Relay 1 = On (Set Closed)

Relay 2 pins 5 (-) and 6 (+)
Any Fault or Alarm or Equipment Power Off
Relay 2 = Off (Set Open)

No Faults or Alarms and Equipment Power On
Relay 2 = On (Set Closed)

Relay 3 pins 3 (-) and 4 (+)
Receive RSL < -100dBm or Equipment Power Off
Relay 3 = Off (Set Open)

Receive RSL > -100dBm and Equipment Power On
Relay 3 = On (Set Closed)

Relay 4 pins 1 (-) and 2 (+)
Pre-BER> 1E-4 or Equipment Power Off
Relay 4 = Off (Set Open)

Pre-BER < 1E-4 and Equipment Power On
Relay 4 = On (Set Closed)

5.9.3.2. Mapping Set 2 and "Map Faults-Relays" Set ON

Relays remain the same as for Mapping 1 but analog output is manually selected by performing the following steps:

On the SL9003Q Tx Main Menu
Use Up or Down arrow to select `System`
`<Enter>`
Scroll down to `External I/O`
`<Enter>`
Scroll down four times
Use left or right arrow to set analog output (see table in Mapping 1)
`<Enter>`
`<Escape>`
`<Escape>`
Use left or right arrow to select `Yes` to save settings
`<Enter>`

5.9.3.3. Mapping Set 0 and "Map Faults-Relays" Set ON

Analog output is manually selected. The relays are set as follows (refer to section 4.4.10 for corresponding menu screens):

Relay 1 pins 7 (-) and 8 (+)
Receiver Synth UNLock Status Exist or Equipment Power Off
Relay 1 = Off (Set Open)

Receiver Synth Lock Status Exist and Equipment Power On
Relay 1 = On (Set Closed)

Relay 2 pins 5 (-) and 6 (+)
One or more Transmitter Alarm Status Exist or Equipment Power Off
Relay 2 = Off (Set Open)

No Transmitter Alarm Status Exist and Equipment Power On
Relay 2 = On (Set Closed)

Relay 3 pins 3 (-) and 4 (+)
QAM Mod UNLock Alarm Status Exist or Equipment Power Off
Relay 3 = Off (Set Open)

QAM Mod Lock Alarm Status Exist and Equipment Power On
Relay 3 = On (Set Closed)

Relay 4 pins 1 (-) and 2 (+)
Demod UNLock or Equipment Power Off
Relay 4 = Off (Set Open)

Demod Lock and Equipment Power On
Relay 4 = On (Set Closed)

5.9.4 NMS External Output Characteristic

The NMS monitor output (Ext I/O pin 10) may be set for Received Signal Level (receiver) and Forward Power (transmitter) as described above in Section 5.9.2.1 (see Section 4.4.10 for corresponding menu screens). Figure 5-18 shows the representative output characteristic for the receiver RSL.

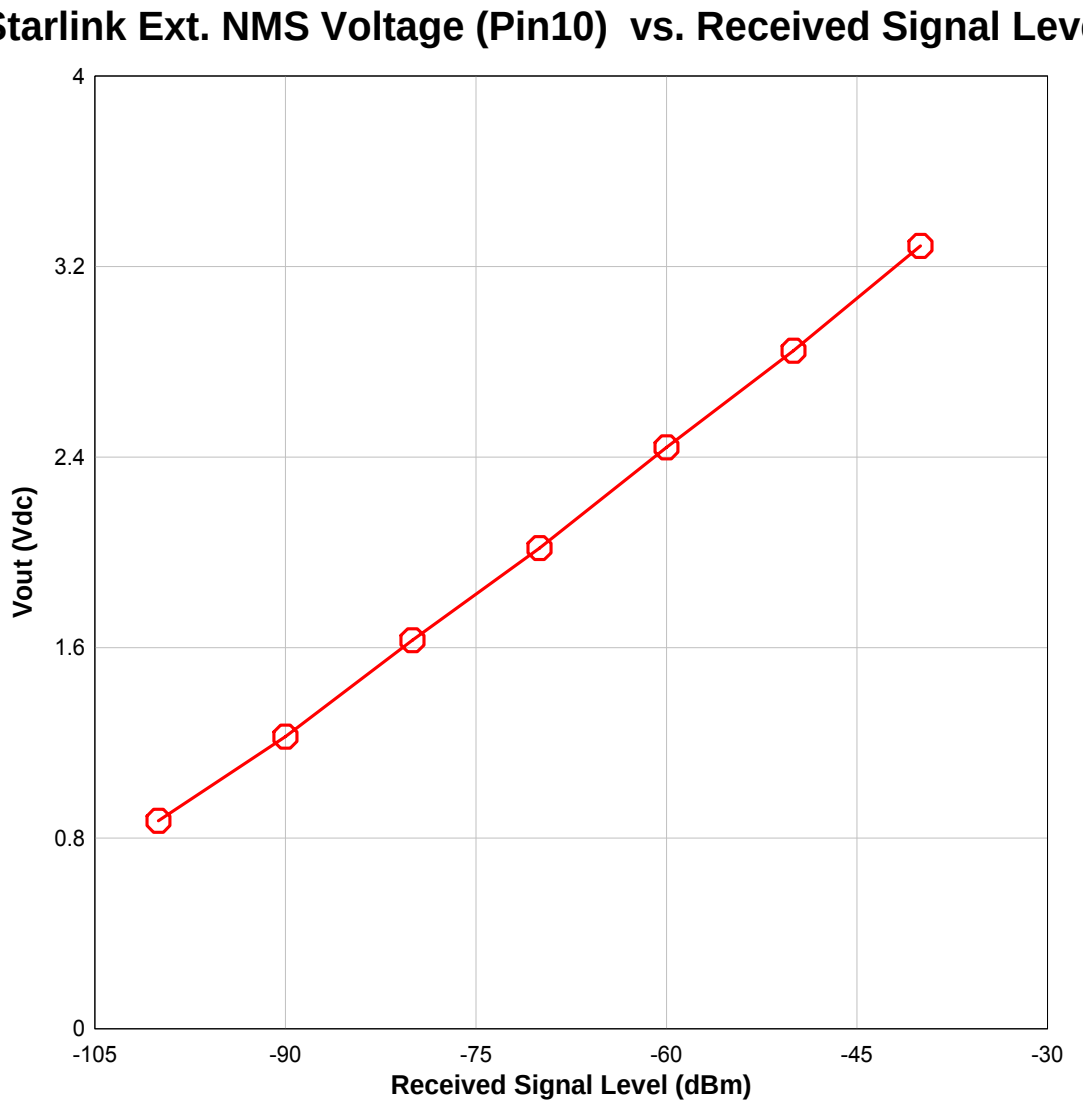


Figure 5-18 NMS External RSL Voltage Curve (Pin 10)

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6 Customer Service

6.1 Introduction

Moseley Associates will assist its product users with difficulties. Most problems can be resolved through telephone consultation with our technical service department. When necessary, factory service may be provided. If you are not certain whether factory service of your equipment is covered, please check your product Warranty/Service Agreement.

Do not return any equipment to Moseley without prior consultation.

The solutions to many technical problems can be found in our product manuals; please read them and become familiar with your equipment.

We invite you to visit our Internet web site at http://www.moseleysb.com/.

6.2 Technical Consultation

Please have the following information available prior to calling the factory:

- Model number and serial number of unit;
- Shipment date or date of purchase of an Extended Service Agreement;
- Any markings on suspected subassemblies (such as revision level); and
- Factory test data, if applicable.

Efficient resolution of your problem will be facilitated by an accurate description of the problem and its precise symptoms. For example, is the problem intermittent or constant? What are the front panel indications? If applicable, what is your operating frequency?

Technical consultation is available at (805) 968-9621 from 8:00 a.m. to 5:00 p.m., Pacific Time, Monday through Friday. During these hours a technical service representative who knows your product should be available. If the representative for your product is busy, your call will be returned as soon as possible. Leave your name, station call letters if applicable, type of equipment, and telephone number(s) where you can be reached in the next few hours.

Please understand that, in trying to keep our service lines open, we may be unable to provide "walk-through" consultation. Instead, our representative will usually suggest the steps to resolve your problem; try these steps and, if your problem remains, do not hesitate to call back.

After-Hours Emergencies
Emergency consultation is available through the same telephone number from 5:00 p.m. to 10:00 p.m. Pacific Time, Monday to Friday, and from 8:00 a.m. to 10:00 p.m. Pacific Time on weekends and holidays. Please do not call during these hours unless you have an emergency with installed equipment. Our representative will not be able to take orders for parts, provide order status information, or assist with installation problems.

6.3 Factory Service

Arrangements for factory service should be made only with a Moseley technical service representative. You will be given a Return Authorization (RA) number. This number will expedite the routing of your equipment directly to the service department. Do not send any equipment to Moseley Associates without an RA number.

When returning equipment for troubleshooting and repair, include a detailed description of the symptoms experienced in the field, as well as any other information that well help us fix the problem and get the equipment back to you as fast as possible. Include your RA number inside the carton.

If you are shipping a complete chassis, all modules should be tied down or secured as they were originally received. On some Moseley Associates equipment, printing on the underside or topside of the chassis will indicate where shipping screws should be installed and secured.

Ship equipment in its original packing, if possible. If you are shipping a subassembly, please pack it generously to survive shipping. Make sure the carton is packed fully and evenly without voids, to prevent shifting. Seal it with appropriate shipping tape or nylon-reinforced tape. Mark the outside of the carton "Electronic Equipment - Fragile" in large red letters. Note the RA number clearly on the carton or on the shipping label, and make sure the name of your company is listed on the shipping label. Insure your shipment appropriately. All equipment must be shipped prepaid.

The survival of your equipment depends on the care you take in shipping it.

Address shipments to:

MOSELEY ASSOCIATES, INC.
Attn: Technical Services Department
111 Castilian Drive
Santa Barbara, CA 93117-3093

Moseley Associates, Inc. will return the equipment prepaid under Warranty and Service Agreement conditions, and either freight collect or billed for equipment not covered by Warranty or a Service Agreement.

6.4 Field Repair

Some Moseley Associates equipment will have stickers covering certain potentiometers, varicaps, screws, and so forth. Please contact Moseley Associates technical service department before breaking these stickers. Breaking a tamperproof sticker may void your warranty.

When working with Moseley's electronic circuits, work on a grounded antistatic surface, wear a ground strap, and use industry-standard ESD control.

Try to isolate a problem to a module or to a specific section of a module. Then compare actual wave shapes and voltage levels in your circuit with any shown on the block and level diagrams or schematics. These will sometimes allow the problem to be traced to a component.

Spare Parts Kits
Spare parts kits are available for all Moseley Associates products. We encourage the purchase of the appropriate kits to allow self-sufficiency with regard to parts. Information about spares kits for your product may be obtained from our sales department or technical service department.

Module Exchange
When it is impossible or impractical to trace a problem to the component level, replacing an entire module or subassembly may be a more expedient way to correct the problem. Replacement modules are normally available at Moseley Associates for immediate shipment. Arrange delivery of a module with our technical services representative. If the shipment is to be held at your local airport with a telephone number to call, please provide an alternate number as well. This can prevent unnecessary delays.

Field Repair Techniques

If an integrated circuit is suspect, carefully remove the original and install the new one, observing polarity. Installing an IC backward may damage not only the component itself, but the surrounding circuitry as well. ICs occasionally exhibit temperature-sensitive characteristics. If a device operates intermittently, or appears to drift, rapidly cooling the component with a cryogenic spray may aid in identifying the problem.

If a soldered component must be replaced, do the following:

- Use a 40W maximum soldering iron with an 1/8-inch maximum tip. Do not use a soldering gun. Excessive heat can damage components and the printed circuit. Surface mount devices are especially heat sensitive, and require a lower power soldering iron. If you are not experienced with surface mount components, we suggest that you do not learn on critical equipment.

- Remove the solder from the component leads and the printed circuit pads. Solder wicking braid or a vacuum de-solderer is useful for this. Gently loosen the component leads and extract the component from the board.

- Form the leads of the replacement component to fit easily into the circuit board pattern.

- Solder each lead of the component to the bottom side of the board, using a good brand of rosin-core solder. We recommend not using water soluble flux, particularly in RF portions of the circuit. The solder should flow through the hole and form a fillet on both sides. Fillets should be smooth and shiny, but do not overheat the component trying to obtain this result.

- Trim the leads of the replacement component close to the solder on the pad side of the printed circuit board with a pair of diagonal cutters.

- Completely remove all residual flux with a cotton swab moistened with flux cleaner.

- For long term quality, inspect each solder joint – top and bottom – under a magnifier and rework solder joints to meet industry standards. Inspect the adjacent components soldered by the Moseley Associates production line for an example of high reliability soldering.

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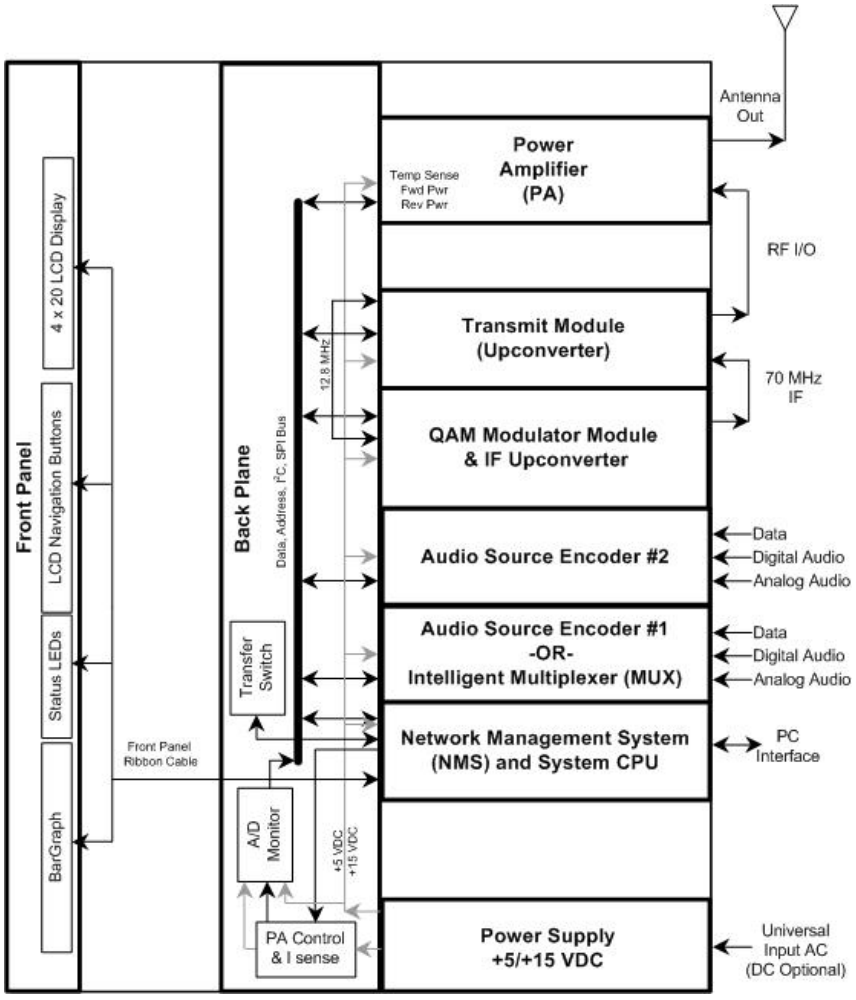
7 System Description

7.5 Introduction

The SL9003Q consists of a transmitter (TX) and receiver (RX) pair of units that are matched in frequency and modulation/demodulation characteristics. The following sections describe the TX system, RX system, followed by sub-system components. Please reference the accompanying block diagrams for reference and clarification.

We will follow the typical end-to-end progression of a radio system starting with the TX baseband inputs, to the QAM modulator, followed by the up-conversion process and the power amplifier. We then proceed to the RX preamplifier input, the down-conversion process, followed by the QAM demodulator and baseband outputs.

7.6 Transmitter



Fiigure 7-1 SL9003Q Transmitter System Block Diagram

The SL9003Q TX is a modular digital radio transmitter system that operates in multiple RF bands (160-240, 330-512, 800-960, 1340-1520, and 1650-1700 MHz) and provides simplex data transmission up to 2.048 Mbps increments in 8 kbps steps. The block diagram in Figure 7-1 shows operational block partitions that also represent the physical partitions within the system.

All modules (excluding the Front Panel) are interconnected via the backplane which traverses the entire width of the unit. The backplane contains the various communication buses as well as the PA (Power Amplifier) control and redundant transfer circuitry. The power supply levels and status are monitored on the backplane and the NMS/CPU card processes the data.

The NMS/CPU card incorporates microprocessor and FPGA logic to configure and monitor the overall operation of the system via front panel controls, LCD screen menus, status LED's and the bar graph display. Module settings are loaded into the installed cards and power-up default settings are stored in non-volatile memory. LCD screen menu software is uploaded into memory, providing field upgrade capability. A Windows-based PC interface is available for connection at the rear panel DATA port.

7.6.1. Audio Encoder

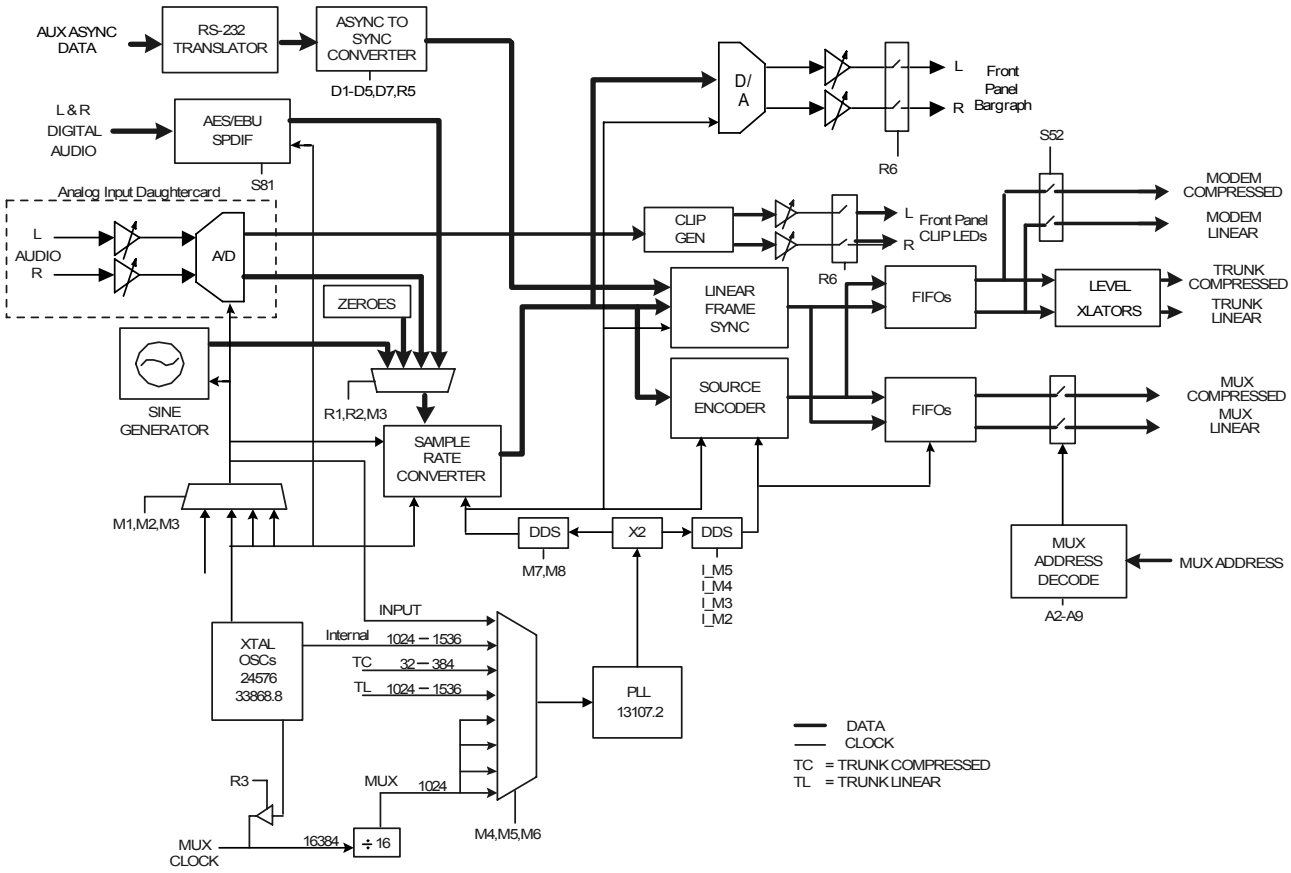


Figure 7-2 Audio Encoder Block Diagram

The Audio Encoder module directly receives and decodes the AES/EBU digital audio into a digital stereo audio data stream. Optionally, the analog audio inputs can be used (located on the Analog Input daughtercard), and these inputs are converted to 16 bit digital stereo data. The SRC (sample rate converter) passes the digital audio data stream to a data multiplexer while synchronizing/converting the incoming sample rate (30-50 kHz) to the internal sample rate clock (32, 44.1, 48 kHz selectable). For example, data could be provided by a CD player at 44.1 kHz, while the internal sample rate to be transmitted across the link is at 32 kHz (the default rate).

The digital audio is optionally compressed (using MPEG) in the Audio Encoder module to allow for higher bandwidth efficiency (more audio channels per RF channel) at the expense of aural masking compression disadvantages. However, some users may require the compression algorithm for existing system compatibility.

Sine wave and “zeroes” test signal generators are available on the card (switch selectable) for system testing. The stereo D/A converter transforms the signal back to analog for use in monitoring the signal from the front panel. This conveniently allows for level monitoring of the digital AES/EBU audio inputs on the bar graph.

The digital audio data (linear or compressed) and the auxiliary data channel are subsequently coded into a single data stream. In a 2 channel system, this data stream is sent to the QAM Modulator module directly.

7.6.2. Intelligent Multiplexer

The MUX is documented in a separate user manual. Typical broadcast applications are described here:

4-Port Mux:
For composite STL systems, the 4-port mux (with composite option card) is used to route and multiplex the composite signal to the QAM modulator.

6-Port Mux:
For discrete STL systems, the 6-port mux (with Ethernet option card) is primarily used to interface and multiplex an Ethernet data stream for transmission as a data channel.

7.6.3. QAM Modulator/IF Upconverter Daughter Card

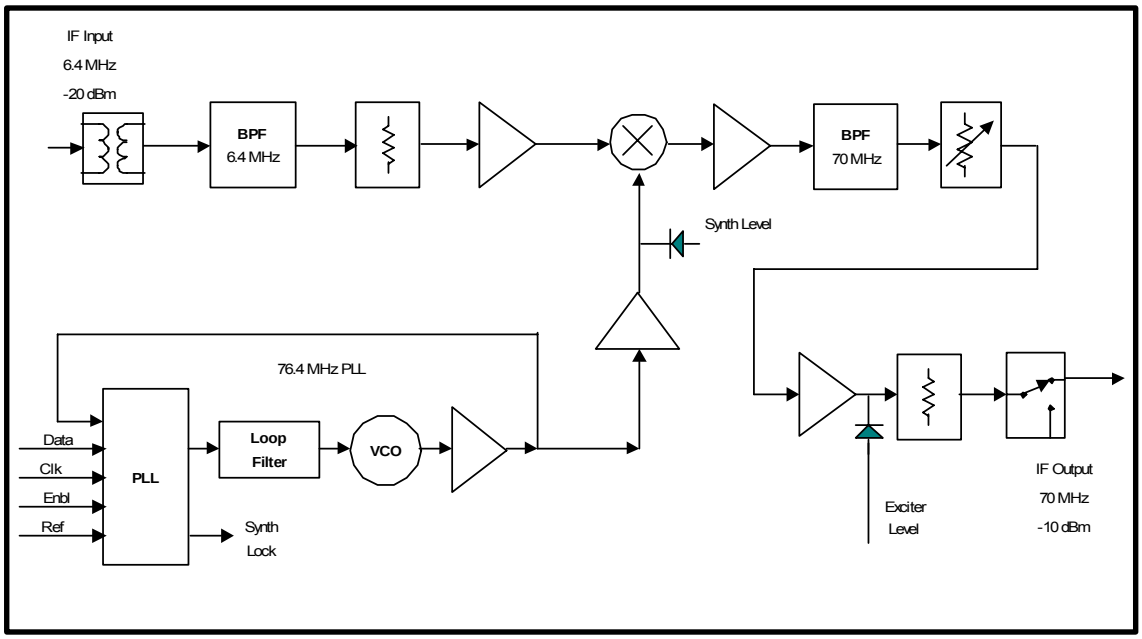


Figure 7-3 IF Upconverter Daughter Card Block Diagram

The QAM (Quadrature Amplitude Modulation) Modulator accepts the aggregate data stream via the backplane. The module performs up to 256 QAM modulation at a carrier frequency of 6.4 MHz, adding FEC (Forward Error Correction) bits while interleaving the blocks of data. The result is a very spectrally efficient, yet robust linear modulation scheme. This process requires an ultra-stable master clock provided by an OCXO (oven controlled crystal oscillator) that is accurate to within 0.1 ppm.

The resultant carrier is translated up to 70 MHz by the IF Upconverter daughter card (located in the same module). This is accomplished by a standard mixing of the carrier with a phase-locked LO. A 70 MHz SAW filter provides an exceptional, spectrally-clean output signal.

7.6.4. Transmit Module (Upconverter)

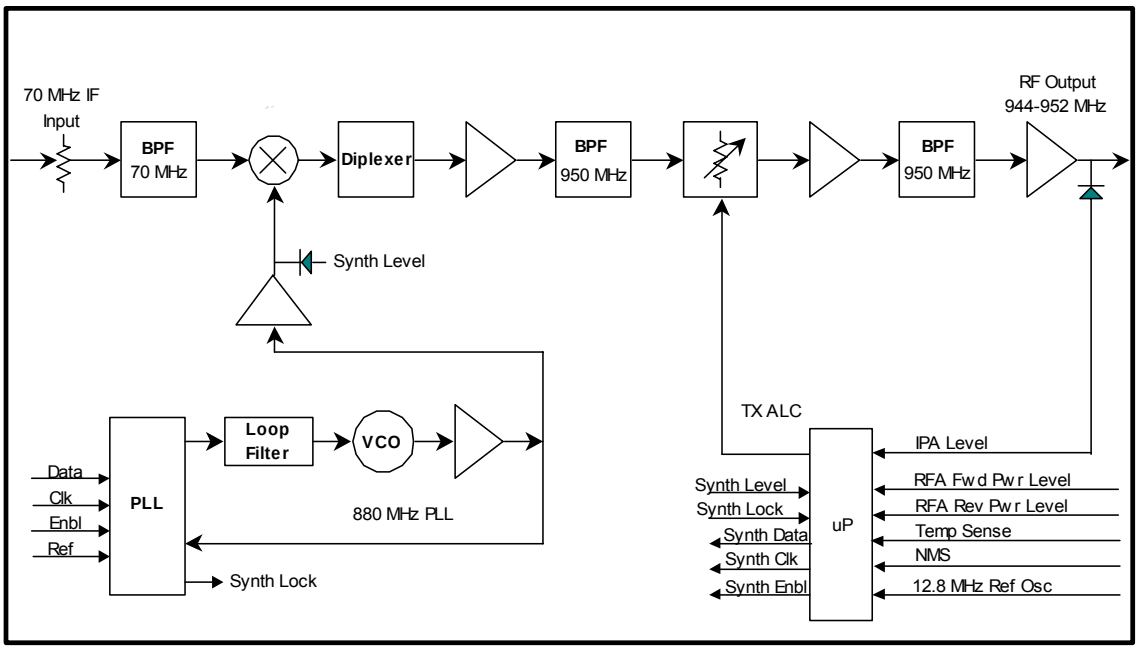


Figure 7-4 Transmit Module (Upconverter) Block Diagram

The RF output carrier of the IF Upconverter is fed to the Upconverter via an external (rear panel) semi-rigid SMA cable. This module performs the necessary conversion to the carrier frequency. There is an on-board CPU for independent control of the critical RF parameters of the system.

Since this is a linear RF processing chain, an automatic leveling control loop (ALC) is implemented here to maintain maximum available power output (and therefore maximum system gain). The ALC monitors the PA forward power (FWD) output sample, and controls the Upconverter gain per an algorithm programmed in the CPU. The ALC also controls the power-up RF conditions of the transmitter output.

7.6.5. Power Amplifier

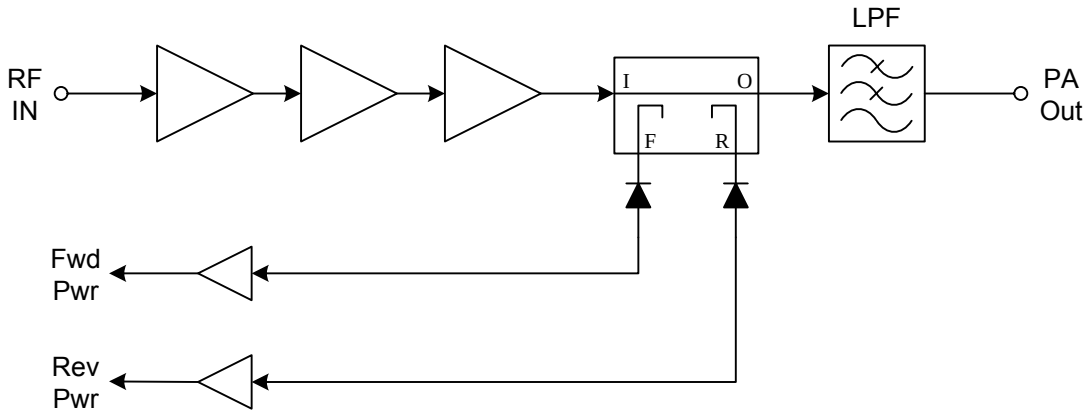


Figure 7-5 SL9003Q RF Power Amplifier Block Diagram

The Power Amplifier (PA) is a separate module that is mounted to a heatsink and is fan-cooled for reliable operation. The PA is a design for maximum linearity in an amplitude modulation-based system. Forward and reverse (reflected) power are detected and sampled to provide metering and ALC feedback.

7.7 Receiver

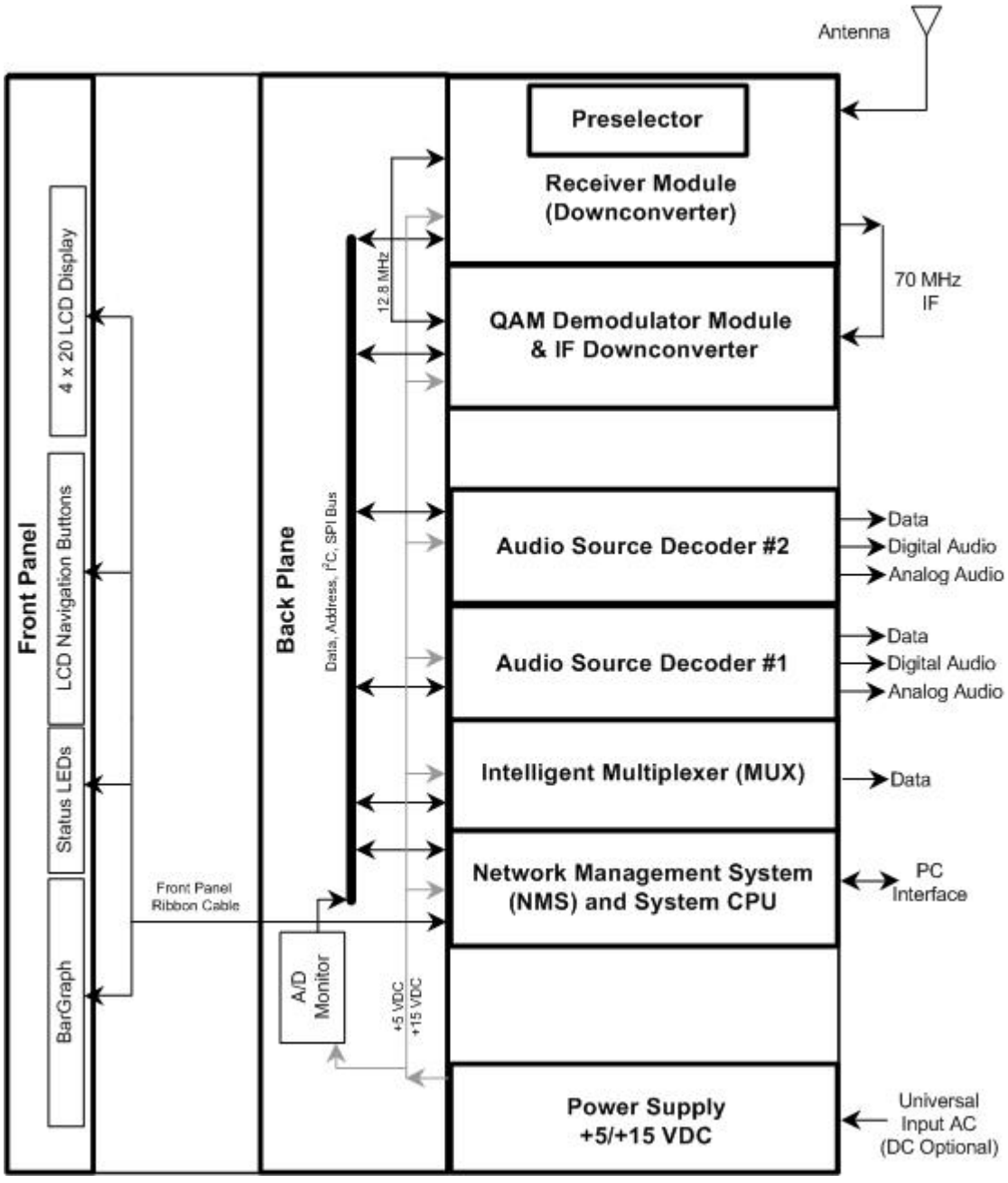


Figure 7-6 SL9003Q Receiver System Block Diagram

The SL9003Q RX is a modular digital radio receiver system that operates in multiple RF bands (160-240, 330-512, 800-960, 1340-1520, and 1650-1700 MHz), and provides simplex data transmission up to 2.048 Mbps increments in 8 kbps steps. The block diagram in Figure 7-6 shows operational block partitions that also represent the physical partitions within the system.

All modules (excluding the Front Panel) are interconnected via the Backplane which traverses the entire width of the unit. The Backplane contains the various communication buses as well as the redundant transfer circuitry. The power supply levels and status are monitored and the NMS/CPU card processes the data.

The NMS/CPU card incorporates microprocessor and FPGA logic to configure and monitor the overall operation of the system via front panel controls, LCD screen menus, status LEDs and the bar graph display. Module settings are loaded into the installed cards and power-up default settings are stored in non-volatile memory. LCD screen menu software is uploaded into memory, providing field upgrade capability. A Windows-based PC interface is available for connection at the rear panel DATA port.

7.7.1. Receiver Module

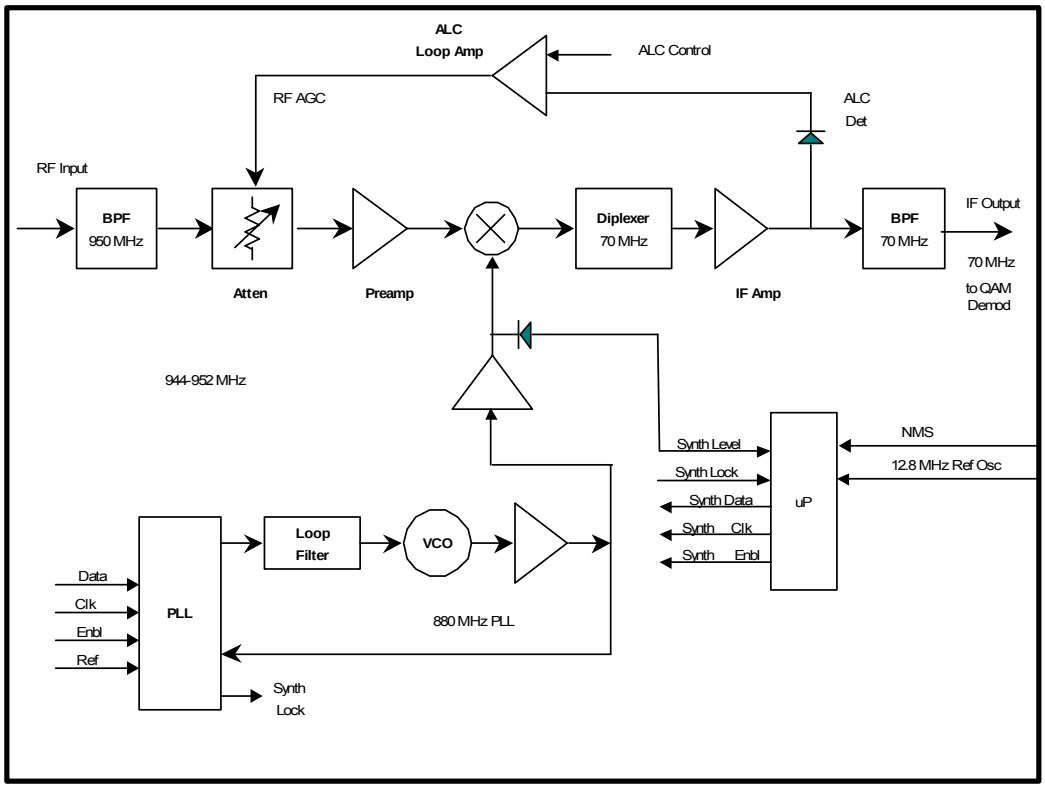


Figure 7-7 Receiver Module Block Diagram

The receiver handles the traditional down-conversion from the RF carrier to the 70 MHz IF. Considerations are given to image rejection, intermodulation performance, dynamic range, agility, and survivability. A separate AGC loop was assigned to the RF front end to prevent intermodulation and saturation problems associated with reception of high level undesirable interfering RF signals resulting from RF bandwidth that is much wider than the IF bandwidth. The linear QAM scheme is fairly intolerant of amplifier overload. These problems are typically related to difficult radio interference environments that include high power pagers, cellular phone sites, and vehicle location systems.

7.7.2. QAM Demodulator/IF Downconverter Daughter Card

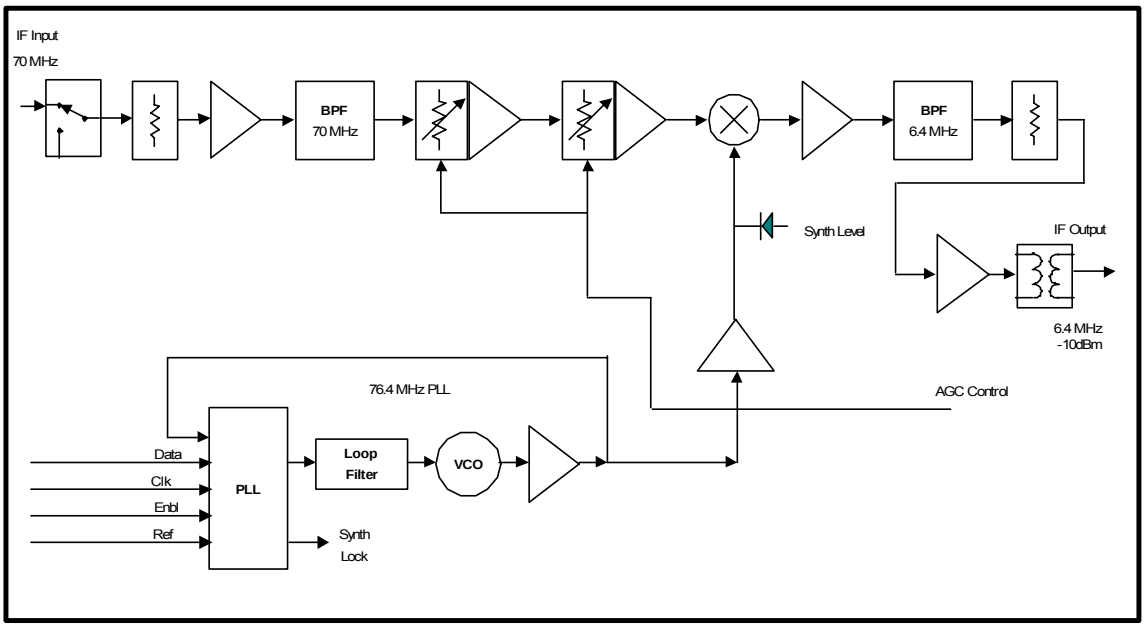


Figure 7-8 SL9003Q IF Downconverter Daughter Card Block Diagram

The QAM (Quadrature Amplitude Modulation) Demodulator module consists of an IF Downconverter and a QAM Demodulator card.

The IF Downconverter receives the 70 MHz carrier from the Receiver Module via an external semi-rigid cable and directly converts the carrier to 6.4 MHz by mixing with a low-noise phase-locked LO. System selectivity is achieved through the use of a 70 MHz SAW filter.

The QAM Demod receives and demodulates the 6.4 MHz carrier. The demodulation process includes the FEC implementation and de-interleaving that matches the QAM modulator in the transmitter, and the critical "data assisted recovery" of the clock. This process requires an ultra-stable master clock provided by an OCXO (oven controlled crystal oscillator) that is accurate to within 0.1 ppm.

The output is an aggregate data stream that is distributed to either the MUX or the Audio Decoder via the backplane.

7.7.3. Intelligent Multiplexer

The MUX is documented in a separate user manual. Typical broadcast applications are described here:

4-Port Mux:
For composite STL systems, the 4-port mux (with composite option card) is used to route and demultiplex the composite signal from the QAM demodulator.

6-Port Mux:
For discrete STL systems, the 6-port mux (with Ethernet option card) is primarily used to interface and demultiplex the Ethernet data stream from the QAM demodulator.

7.7.4. Audio Decoder

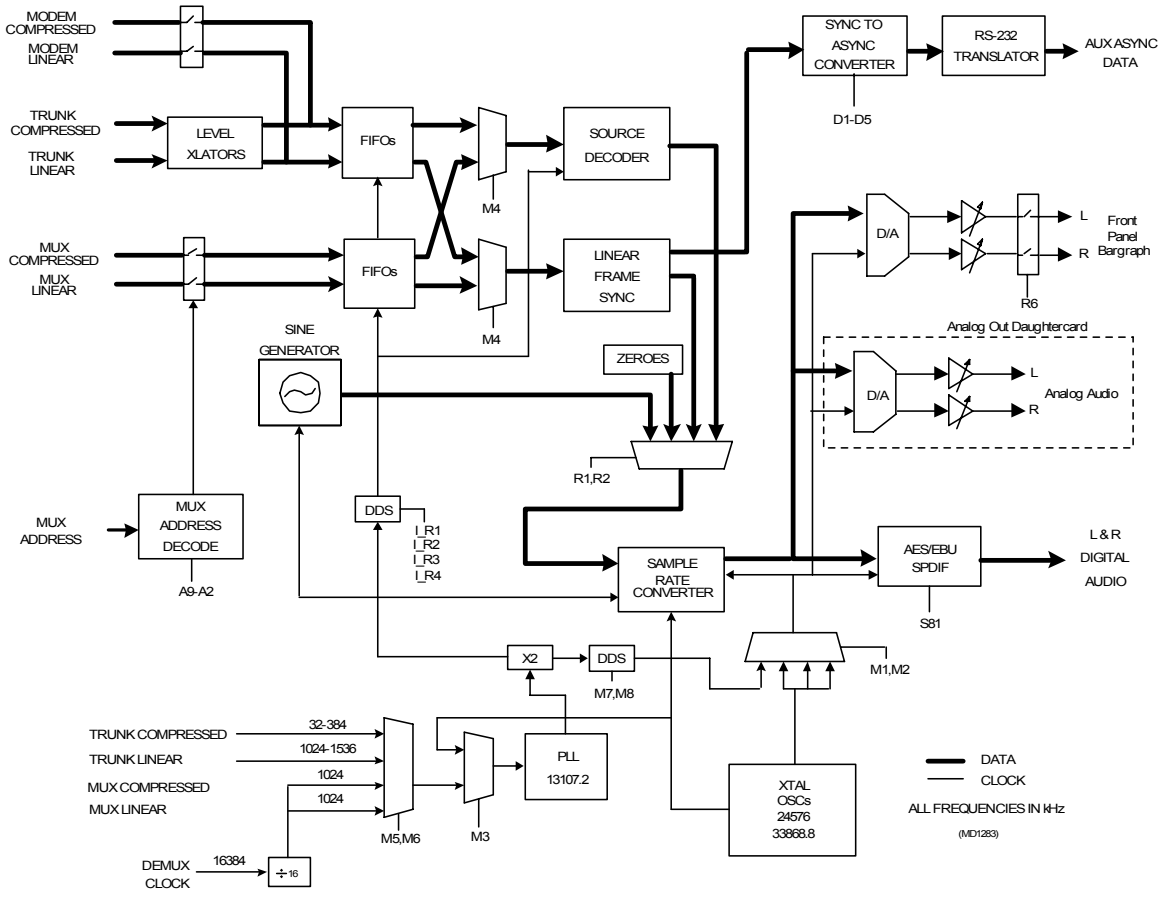


Figure 7-9 Audio Decoder Block Diagram

The Audio Decoder module accepts the data stream and the recovered clock from the backplane (QAM Demod or the MUX). This data (compressed or linear) is fed to the FIFOs (First In. First Out) buffers. The data is then passed through the FIFOs to an initial data multiplexer. Sine wave and "zeros" test signal generators are available on the card (switch selectable) for system testing.

Compressed: The audio decoder add-on card decodes the compressed data per the appropriate algorithm (ISO/MPEG). This decoded information is then passed on to the Sample Rate Converter (SRC) via a second data multiplexer.

Linear: Using embedded coding, the linear inputs received are analyzed and then synchronized for transmission to the Sample Rate Converter via a second data multiplexer.

The second data multiplexer chip selects which of the three inputs (Compressed Audio Decoder, Linear Frame Sync, or Internal Sine Generator) will be sent to the SRC. As an option, zeros can also be sent through the multiplexer chip to test the noise floor.

The SRC receives the data stream via the second data multiplexer. This information is compared to the clock rate determined at switches M7 and M8 for conversion to the final output decoding segment.

From the SRC, the data is bussed to the AES/EBU encoder for left and right digital audio output, to the 16 bit D/A converter (located on the Analog Out daughtercard) for the main analog channel outputs, and to a 12 bit D/A converter that provides an analog output to the bar graph monitor on the front panel.

The clock source provides the ability to synchronize the various components of the system with a single device, such as the on-board crystal oscillator, the internal multiplexer clock, the bus, the AES/EBU input, the trunk, etc. The user can determine whether the card will generate its own clock or whether it will use a different source's clock as reference. This information is then sent to the SRC for conversion of the incoming data to the rate of desired output.

8 Appendices

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Appendix A: Path Evaluation Information

*Please visit **www.moseleybroadcast.com** and click on **support** for online Path Evaluation resources or simply telephone Moseley Customer Services for help in this area.*

A.1. Introduction

A.1.1 Line of Site

For the proposed installation sites, one of the most important immediate tasks is to determine whether line-of-site is available. The easiest way to determine line-of-site is simply to visit one of the proposed antenna locations and look to see that the path to the opposite location is clear of obstructions. For short distances, this may be done easily with the naked eye, while sighting over longer distances may require the use of binoculars. If locating the opposing site is difficult, you may want to try using a mirror, strobe light, flag, weather balloon or compass (with prior knowledge of site coordinates).

A.1.2 Refraction

Because the path of a radio beam is often referred to as line-of-site, it is often thought of as a straight line in space from transmitting to receiving antenna. The fact that it is neither a line, nor is the path straight, leads to the rather involved explanations of its behavior.
A radio beam and a beam of light are similar in that both consist of electromagnetic energy; the difference in their behavior is principally due to the difference in frequency. A basic characteristic of electromagnetic energy is that it travels in a direction perpendicular to the plane of constant phase; i.e., if the beam were instantaneously cut at right angle to the direction of travel, a plane of uniform phase would be obtained. If, on the other hand, the beam entered a medium of non-uniform density and the lower portion of the beam traveled through the denser portion of the medium, its velocity would be less than that of the upper portion of the beam. The plane of uniform phase would then change, and the beam would bend downward. This is refraction, just as a light beam is refracted when it moves through a prism.
The atmosphere surrounding the earth has the non-uniform characteristics of temperature, pressure, and relative humidity, which are the parameters that determine the dielectric constant, and therefore the velocity of radio wave propagation. The earth's atmosphere is therefore the refracting medium that tends to make the radio horizon appear closer or farther away.

A.1.3 Fresnel Zones

The effect of obstacles, both in and near the path, and the terrain, has a bearing on the propagation of radio energy from one point to another. The nature of these effects depends upon many things, including the position, shape, and height of obstacles, nature of the terrain, and whether the effects of concern are primary or secondary effects.

Primary effects, caused by an obstacle that blocks the direct path, depend on whether it is totally or partially blocking, whether the blocking is in the vertical or the horizontal plane, and the shape and nature of the obstacle.

The most serious of the secondary effects is reflection from surfaces in or near the path, such as the ground or structures. For shallow angle microwave reflections, there will be a 180° (half wavelength) phase shift at the reflection point. Additionally, reflected energy travels farther and arrives later, directly increasing the phase delay. The difference in distance traveled by the direct waves and the reflected waves, expressed in wavelengths of the carrier frequency, is added to the half wavelength delay caused by reflection. Upon arrival at the receiving antenna, the reflected signal is likely to be out of phase with the direct signal, and may tend to add to or cancel the direct signal. The extent of direct signal cancellation (or augmentation) by a reflected signal depends on the relative powers of the direct and the reflected signals, and on the phase angle between them.

Maximum augmentation will occur when the signals are exactly in phase. This will be the case when the total phase delay is equal to one wavelength (or equal to any integer multiple of the carrier wavelength); this will also be the case when the distance traveled by the reflected signal is longer than the direct path by an odd number multiple of one-half wavelength. Maximum cancellation will occur when the signals are exactly out of phase, or when the phase delay is an odd multiple of one-half wavelength, which will occur when the reflected waves travel an integer multiple of the carrier wavelength farther than the direct waves. Note that the first cancellation maximum on a shallow angle reflective path will occur when the phase delay is one and one-half wavelengths, caused by a path one wavelength longer than the direct path.

The direct radio path, in the simplest case, follows a geometrically straight line from transmitting antenna to receiving antenna. However, geometry shows that there exist an infinite number of points from which a reflected ray reaching the receiving antenna will be out of phase with the direct rays by exactly one wavelength. In ideal conditions, these points form an ellipsoid of revolution, with the transmitting and receiving antennas at the foci. This ellipsoid is defined as the first Fresnel zone. Any waves reflected from a surface that coincides with a point on the first Fresnel zone, and received by the receiving antenna, will be exactly in phase with the direct rays. This zone should not be violated by intruding obstructions, except by specific design amounts. The first Fresnel zone, or more accurately the first Fresnel zone radius, is defined as the perpendicular distance from the direct ray line to the ellipsoidal surface at a given point along the microwave path. It is calculated as follows:

$$F1 = 2280 \times [(d1 \times d2) / (f \times (d1+d2))]^{1/2} \text{ feet}$$

Where,

d1 and d2 = distances in statute miles from a given point on a microwave path to the ends of the path (or path segment).

f = frequency in MHz.

F1 = first Fresnel zone radius in feet.

There are in addition, of course, the second, third, fourth, etc. Fresnel zones, and these may be easily computed, at the same point along the microwave path, by multiplying the first Fresnel zone radius by the square root of the desired Fresnel zone number. All odd numbered Fresnel zones are additive, and all even numbered Fresnel zones are canceling.

A.1.4 K Factors

The matter of establishing antenna elevations to provide minimum fading would be relatively simple was it not for atmospheric effects. The antennas could easily be placed at elevations somewhere between free space loss and first Fresnel zone clearance over the predominant surface or obstruction, reflective or not, and the transmission would be expected to remain stable. Unfortunately, the effective terrain clearance changes, due to changes in the air dielectric with consequent changes in refractive bending.

As described earlier, the radio beam is almost never a precisely straight line. Under a given set of meteorological conditions, the microwave ray may be represented conveniently by a straight line instead of a curved line if the ray is drawn on a fictitious earth representation of radius K times that of earth's actual radius. The K factor in propagation is thus the ratio of effective earth radius to actual earth radius. The K factor depends on the rate of change of refractive index with height and is given as:

K = 157/(157+dN/dh)

Where,

N is the radio refractivity of air.

dN/dh is the gradient of N per kilometer.

The **radio refractivity** of air for frequencies up to 30 GHz is given as:

N = (77.6P/T) + (3.73 x 105)(e/T2)

Where,

P = total atmospheric pressure in millibars.

T = absolute temperature in degrees Kelvin.

e = partial pressure of water vapor in millibars.

The P/T term is frequently referred to as the "dry" term and the e/T2 term as the "wet" term.

K factors of 1 are equivalent to no ray bending, while K factors above 1 are equivalent to ray bending away from the earth's surface and K factors below 1 (earth bulging) are equivalent to ray bending towards the earth's surface. The amount of earth bulge at a given point along the path is given by:

h = (2d1xd2)/3K

Where,

h = earth bulge in feet from the flat-earth reference.

d1 = distance in miles (statute) from a given end of the microwave path to an arbitrary point along the path.

d2 = distance in miles (statute) from the opposite end of the microwave path to the same arbitrary point along the path.

K = K-factor considered.

Three K values are of particular interest in this connection:

1. Minimum value to be expected over the path. This determines the degree of "earth bulging" and directly affects the requirements for antenna height. It also establishes the lower end of the clearance range over which reflective path analysis must be made, in the case of paths where reflections are expected.

2. Maximum value to be expected over the path. This leads to greater than normal clearance and is of significance primarily on reflective paths, where it establishes the upper end of the clearance range over which reflective analysis must be made.

3. Median or "normal" value to be expected over the path. Clearance under this condition should be at least sufficient to give free space propagation on non-reflective paths. Additionally, on paths with significant reflections, the clearance under normal conditions should not fall at or near an even Fresnel zone.

For most applications the following criteria are considered acceptable:

K = 1.33 and CF = 1.0 F1

K = 1.0 and CF = 0.6 F1

K = 0.67 and CF = 0.3 F1

Where CF is the Fresnel zone clearance and F1 is the first Fresnel zone radius.

A.1.5 Path Profiles

Using ground elevation information obtained from the topographical map, a path profile should be prepared using either true earth or 4/3 earth's radius graph paper. To obtain a clear path, all obstacles in the path of the rays must be cleared by a distance of 0.6 of the first Fresnel zone radius. Be sure to include recently erected structures, such as buildings, towers, water tanks, and so forth, that may not appear on the map. Draw 0a straight line on the path profile clearing any obstacle in the path by the distance determined above. This line will then indicate the required antenna and/or tower height necessary at each end. If it is impossible to provide the necessary clearance for a clear path, a minimum clearance of 30 feet should be provided. Any path with less than 0.6 first Fresnel zone clearance, but more than 30 feet can generally be considered a grazing path.

A.2. Path Analysis

A.2.1 Overview

Path analysis is the means of determining the system performance as a function of the desired path length, required equipment configuration, prevailing terrain, climate, and characteristics of the area under consideration. The path analysis takes into account these parameters and yields the net system performance, referred to as path availability (or path reliability). Performing a path analysis allows you to specify the antenna sizes required to achieve the required path availability.
A path analysis is often the first thing done in a feasibility study. The general evaluation can be performed before expending resources on a more detailed investigation.

The first order of business for performing a path analysis is to complete a balance sheet of gains and losses of the radio signal as it travels from the transmitter to the receiver. "Gain" refers to an increase in output signal power relative to input signal power, while "loss" refers to signal attenuation, or a reduction in power level ("loss" does not refer to total interruption of the signal). Both gains and losses are measured in decibels (dB and dBm), the standard unit of signal power.

The purpose of completing the balance sheet is to determine the power level of the received signal as it enters the receiver electronics—in the absence of multipath and rain fading; this is referred to as the unfaded received signal level. Once this is known, the fade margin of the system can be determined. The fade margin is the difference between the unfaded received signal level and the receiver sensitivity (the minimum signal level required for proper receiver operation).

The fade margin is the measure of how much signal attenuation due to multipath and rain fading can be accommodated by the radio system while still achieving a minimum level of performance. In other words, the fade margin is the safety margin against loss of transmission, or transmission outage.

A.2.2 Losses

Although the atmosphere and terrain over which a radio beam travels have a modifying effect on the loss in a radio path, there is, for a given frequency and distance, a characteristic loss. This loss increases with both distance and frequency. It is known as the free space loss and is given by:

$$A = 96.6 + 20\log_{10}F + 20\log_{10}D$$

Where,

A = free space attenuation between isotropics in dB.

F = frequency in GHz.

D = path distance in miles.

A.2.3 Path Balance Sheet/System Calculations

A typical form for recording the gains and losses for a microwave path is shown in Section A.2.7. Recall that the purpose of this tabulation is to determine the fade margin of the proposed radio system. The magnitude of the fade margin is used in subsequent calculations of path availability (up time).

The following instructions will aid you in completing the Path Calculation Balance Sheet (see Section A.2.7):

Instructions

A. Line 1. Enter the power output of the transmitter in dBm. Examples: 5w = +37.0 dBm, 6.5w = +38.0 dBm, 7w = +38.5 dBm, 8w = +39.0 dBm (dBm = 30 + 10 Log Po [in watts]). For the standard 9003Q, enter +30 dBm for 64 QAM and +33 dBm for 16 QAM operation.

B. Lines 2 & 3. Enter Transmitter and Receiver antenna gains over an isotropic source. Refer to the Antenna Gain table below for the power gain of the antenna. Note: If the manufacturer quotes a gain in dBd (referred to a dipole), dBi is approximately dBd +1.1 dB.

Table 8-1 Typical Antenna Gain

ANTENNA TYPE	450 MHz BAND	950 MHz BAND
5 element Yagi	12 dBi	12 dBi
Paraflector	16 dBi	20 dBi
4' Dish* (1.2 m)	13 dBi	19 dBi
6' Dish* (1.8 m)	17 dBi	23 dBi
8' Dish* (2.4 m)	19 dBi	25 dBi
10' Dish* (3.0 m)	22 dBi	27 dBi

C. Line 4. Total lines 1, 2, and 3, and enter here. This is the total gain in the proposed system.

D. Line 5. Enter amount of free space path loss as determined by the formula given in Section A.2.2, or see the table below.

Table 8-2 Free Space Loss

DISTANCE	450 MHz	950 MHz
5 Miles (8 km)	104 dB	110 dB
10 Miles (16 km)	110 dB	116 dB
15 Miles (24 km)	114 dB	120 dB
20 Miles (32 km)	116 dB	122 dB
25 Miles (40 km)	118 dB	124 dB
30 Miles (48 km)	120 dB	126 dB

E. Line 6. Enter the total transmitter transmission line loss. Typical losses can be found in Table A3.

Table 8-3 Transmission Line Loss

FREQUENCY BAND	LDF4-50 (per 100 meters)	LDF5-50 (per 100 meters)
330 MHz	4.6 dB	2.4 dB
450 MHz	5.5 dB	2.9 dB
470 MHz	5.7 dB	3.0 dB
950 MHz	8.3 dB	4.6 dB

F. Line 7. Enter the total receiver transmission line loss (see Table A-3 above).

G. Line 8. Enter the total connector losses. A nominal figure of -0.5 dB is reasonable (based on 0.125 dB/mated pair).

H. Line 9. Enter all other miscellaneous losses here. Such losses might include power dividers, duplexers, diplexers, isolators, isocouplers, and the like. Losses are 1.5 dB per terminal. These only apply for full duplex systems.

Table 8-4 Branching Losses

System Type	TX Loss	RX Loss	Total Loss
Non-Standby Full Duplex Terminal (400 MHz)	1.2	1.2	2.4
Hot Standby Full Duplex Terminal (400 MHz)	1.2	4.2	5.4
Non-Standby Full Duplex Terminal (900 MHz)	1.5	1.5	3.0
Hot Standby Full Duplex Terminal (900 MHz)	1.5	4.5	6.0

I. Line 10. Enter obstruction losses due to knife-edge obstructions, etc.

J. Line 11. Total lines 5 to 10 and enter here. This is the total loss in the proposed system.

K. Line 12. Enter the total gain from line 4.

L. Line 13. Enter the total loss from line 11.

M. Line 14. Subtract line 13 from line 12. This is the unfaded signal level to be expected at the receiver. (Convert from dBm to microvolts here for reference).

N. Line 15. Using the information found in Table A-5 below, enter here the minimum signal required for 1x10E-4 BER.

*Table 8-5 Typical Received Signal Strength required for BER of 1x10E-4**

Data Rate Configuration	High Sensitivity 16 QAM	High Efficiency 64 QAM
2 Chnl, 1024 kbps	-93 dBm	-89 dBm
2 Chnl, 1536 kbps	-91.5 dBm	-87.5 dBm
4 Chnl, 1536 kbps	-91.5 dBm	-87.5 dBm
4 Chnl, 2048 kbps	-90 dBm	-86 dBm

* Excludes all branching losses

O. Line 16. Subtract line 15 from line 14 and enter here. This is the amount of fade margin in the system.

P. Line 17. Enter the Terrain Factor.

a (terrain factor)

= 4 for smooth terrain.

= 1 for average terrain.

= 1/4 for mountainous, very rough, or very dry terrain.

Q. Line 18. Enter the Climate Factor.

b (climate factor)

= 1/2 for Gulf coast or similar hot, humid areas.

= 1/4 for normal interior temperate or northern regions.

= 1/8 for mountainous or very dry areas.

R. Line 19. Enter the minimum Annual Outage (from Table A-6).

S. Line 20. Enter the Reliability percentage (from Table A-6).

A.2.4 Path Availability and Reliability

For a given path, the system reliability is generally worked out on methods based on the work of Barnett and Vigants. The presentation here has now been superseded by CCIR 338-6 that establishes a slightly different reliability model. The new model is more difficult to use and, for most purposes, yields very similar results. For mathematical convenience, we will use fractional probability (per unit) rather than percentage probability, and will deal with the unavailability or outage parameter, designated by the symbol U. The availability parameter, for which we use the symbol A, is given by (1-U). Reliability, in percent, as commonly used in the microwave community, is given by 100A, or 100(1-U).

Non-Diversity Annual Outages
Let U_{ndp} be the non-diversity annual outage probability for a given path. We start with a term r, defined by Barnett as follows:

r = actual fade probability/Rayleigh fade probability (=10-F/10)

Where,

F = fade margin, to the minimum acceptable point, in dB.

For the worst month, the fade probability due to terrain is given by:

rm = a x 10-5 x (f/4) x D3

Where,

D = path length in miles.

f = frequency in GHz.

a (terrain factor)

= 4 for smooth terrain.

= 1 for average terrain.

= 1/4 for mountainous, very rough, or very dry terrain.

Over a year, the fade probability due to climate is given by:

$$ryr = b \times rm$$

Where,

b (climate factor)
= 1/2 for Gulf coast or similar hot, humid areas.

= 1/4 for normal interior temperate or northern regions.

= 1/8 for mountainous or very dry areas.

By combining the three equations and noting that Undp is equal to the actual fade probability, for a given fade margin F, we can write:

$$U_{ndp} = ryr \times 10^{-F/10} = b \times rm \times 10^{-F/10}$$

or

$$U_{ndp} = a \times b \times 2.5 \times 10^{-6} \times f \times 10^{D3} \times 10^{-F/10}$$

See Table A-6 for the relationship between system reliability and outage time.

Table 8-6 Relationship Between System Reliability & Outage Time

RELIABILITY (%)	OUTAGE TIME (%)	OUTAGE TIME PER: YEAR		MONTH (Avg.)		DAY	
0	100	8760	Hr	720	hr	24	hr
50	50	4380	Hr	360	hr	12	hr
80	20	1752	hr	144	hr	4.8	hr
90	10	876	hr	72	hr	2.4	hr
95	5	438	hr	36	hr	1.2	hr
98	2	175	hr	14	hr	29	min
99	1	88	hr	7	hr	14.4	min
99.9	0.1	8.8	hr	43	min	1.44	min
99.99	0.01	53	min	4.3	min	8.6	sec
99.999	0.001	5.3	min	26	sec	0.86	sec
99.9999	0.0001	32	Sec	2.6	sec	0.086	sec

A.2.5 Methods Of Improving Reliability

If adequate reliability cannot be achieved by use of a single antenna and frequency, space diversity or frequency diversity (or both) can be used. To achieve space diversity, two antennas are used to receive the signal. For frequency diversity, transmission is done on two different frequencies. For each case the two received signals will not experience fades at the same time. The exact amount of diversity improvement depends on antenna spacing and frequency spacing.

A.2.6 Availability Requirements

Table 8-7 Fade Margins Required for 99.99% Reliability, Terrain Factor of 4.0, and Climate Factor of 0.5

DISTANCE	450 MHz BAND	950 MHz BAND
5 Miles (8 km)	7 dB	10 dB
10 Miles (16 km)	17 dB	20 dB
15 Miles (24 km)	22 dB	25 dB
20 Miles (32 km)	27 dB	30 dB
25 Miles (40 km)	29 dB	32 dB
30 Miles (48 km)	32 dB	35 dB

A.2.7 Path Calculation Balance Sheet

Frequency of operation _____GHz		Distance _____Miles
SYSTEM GAINS		
1.	Transmitter Power Output	_____dBm
2.	Transmitter Antenna Gain	+_____dBi
3.	Receiver Antenna Gain	+_____dBi
4.	**Total Gain (sum of lines 1, 2, 3)**	_____**dB**
SYSTEM LOSSES		
5.	Path loss (_____miles)	-_____dB
6.	Transmission Line Loss TX	
	(Total Ft _____; dB/100 ft)	-_____dB
7.	Transmission Line Loss RX	
	(Total Ft U _____; dB/100 ft)	-_____dB
8.	Connector Loss (Total)	-_____dB
9.	Branching losses	-_____dB
10.	Obstruction losses	-_____dB
11.	**Total loss (sum of lines 5 through 10)**	_____**dB**
SYSTEM CALCULATIONS		
12.	Total Gain (line 4)	+_____dBm
13.	Total Loss (line 11)	-_____dB
14.	**Effective Received Signal**	
	(line 12-line 13) (_____uV)	_____**dBm**
15.	Minimum Signal Required (BER = 1X10E-4)	-_____dBm
16.	**Fade Margin (line 14-line 15)**	_____**dB**
17.	Terrain Factor	_____
18.	Climate Factor	_____
19.	Annual Outage	_____min.
20.	Reliability	_____%

NOTES:

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Appendix B: Audio Considerations

B.1 Units of Audio Measurement

B.1.1 Why dBm?

In the early years of broadcasting and professional audio, audio circuits with matched terminations and maximum power transfer were the common case in studios and for audio transmission lines between facilities. Console and line amplifier output impedances, implemented with vacuum tube and transformer technology, were typically 600 Ohms. Equipment input impedances, again usually transformer-matched, were also typically 600 Ohms. Maximum power transfer takes place when the source and load impedances are matched. For such systems, the dBm unit (dB relative to one milliwatt) was appropriate since it is a power unit.

B.1.2 Audio Meters

However, actual power-measuring instruments are extremely rare in audio. Audio meters and distortions analyzers are voltmeters, measuring voltage across their input terminals. They do not know the power level, current value, nor source impedance across which they are measuring, Since the audio industry had "grown up" with 600 Ohm power-transfer systems in common use, audio test instrument manufacturers typically calibrated their voltmeters for this situation. Most audio test instruments and systems manufactured before approximately 1985 used only Volts and the dBm unit on their meter scales and switch labels. The dBm unit was calibrated with the assumption that the meter would always be connected across a 600 Ohm circuit when measuring dBm. Since the voltage across a 600 Ohm resistor is 0.7746 Volts when one milliwatt is being dissipated in that resistor, the meters were actually calibrated for a zero "dBm" indication with 0.7746 Volts applied. But, they were not measuring power; change the circuit impedance, and the meter is incorrect.

B.1.3 Voltage-Based Systems

Modern audio equipment normally has output impedances much lower than input impedances. Output impedance values from zero up to 50 Ohms are typical, and input impedances of 10 kilohms are typical. Such equipment, connected together, transfers negligible power due to the large impedance mismatch. However, nearly all the source voltage is transferred. As noted earlier, a 10 kilohm load reduces the open-circuit voltage from a 50 Ohm source by only 0.5%, or 0.05 dB. Thus, modern systems typically operate on a voltage transfer basis and the dBm, as a power unit, is not appropriate. A proper unit for voltage-based systems is the dBu (dB relative to 0.7746 Volts). The dBu is a voltage unit and requires no assumptions about current, power, or impedance. Those older audio meters calibrated in "dBm" are really dBu meters.

B.1.4 Old Habits Die Hard

Unfortunately, the “dBm” terminology has hung on long after its use is generally appropriate. Even some of the most competent manufactures of high-technology digital and analog professional audio equipment still use the dBm unit in their setup instructions. Users are told to apply an input signal of “+4 dBm” and then to adjust trim pots for an exact 0 VU indication on a 24-track digital audio tape recorder, for example. Yet, the line input impedances of that tape recorder are 10 kilohms. What the manufacturer clearly wants is a +4 dBu input level (1.22 Volts). If we truly applied +4 dBm to that 10,000 Ohm input, the resulting 5.0 Volts would probably not even be within the trim pot adjustment range for 0 VU. So, a good general rule when working with modern audio equipment unless you know it to be terminated in 600 Ohms is to read the manufacturer’s “dBm” as “dBu”.

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Appendix C: Glossary of Terms

A/D, ADC	Analog-to-Digital, Analog-to-Digital Converter
ADPCM	Adaptive Differential Pulse Code Modulation
AES/EBU	Audio Engineering Society/European Broadcast Union
AGC	Auto Gain Control
ATM	Automatic Teller Machine
BER	Bit Error Rate
CMRR	Common Mode Rejection Ratio
Codec	Coder-Decoder
CPFSK	Continuous-Phase Frequency Shift Keying
CSU	Channel Service Unit
D/A, DAC	Digital-to-Analog, Digital-to-Analog Converter
dB	Decibel
dBc	Decibel relative to carrier
dBm	Decibel relative to 1 mW
dBu	Decibel relative to .775 Vrms
DCE	Data Circuit-Terminating Equipment
DSP	Digital Signal Processing
DSTL	Digital Studio-Transmitter Link
DTE	Data Terminal Equipment
DVM	Digital Voltmeter
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge/Electrostatic Damage
FET	Field effect transistor
FMO	Frequency Modulation Oscillator
FPGA	Field Programmable Gate Array
FSK	Frequency Shift Keying
FT1	Fractional T1
IC	Integrated circuit
IEC	International Electrotechnical Commission
IF	Intermediate frequency
IMD	Intermodulation Distortion
ISDN	Integrated-Services Digital Network
Kbps	Kilobits per second
kHz	Kilohertz
LED	Light-emitting diode
LO, LO1	Local oscillator, first local oscillator
LSB	Least significant bit
MAI	Moseley Associates, Inc.
Mbps	Megabits per second
Modem	Modulator-demodulator
ms	Millisecond
MSB	Most significant bit
MUX	Multiplex, Multiplexer
□s	Microsecond
□V	Microvolts
NC	Normally closed
NMS	Network Management System
NO	Normally open
PCB	Printed circuit board

PCM	Pulse Code Modulation
PGM	Program
PLL	Phase-Locked Loop
QAM	Quadrature Amplitude Modulation
R	Transmission Rate
RF	Radio Frequency
RPTR	Repeater
RSL	Received Signal Level (in dBm)
RSSI	Received Signal Strength Indicator/Indication
RX	Receiver
SCA	Subsidiary Communications Authorization
SCADA	Security Control and Data Acquisition
SNR	Signal-to-Noise Ratio
SRD	Step Recovery Diode
STL	Studio-Transmitter Link
TDM	Time Division Multiplexing
THD	Total harmonic distortion
TP	Test Point
TTL	Transistor-transistor logic
TX	Transmitter
Vrms	Volts root-mean-square
Vp	Volts peak
Vp-p	Volts peak-to-peak
VRMS	Volts, root-mean-square
VSWR	Voltage standing-wave ratio
ZIN	Input Impedance
ZOUT	Output Impedance

Appendix D: Microvolt – dBm – Watt Conversion (50 ohms)

Vrms	dBm	Watts
µV	***dBm***	
0.7	***-110***	***10 fW***
0.8	*-109*	
0.9	*-108*	
1	*-107*	
1.1	*-106*	
1.2	*-105*	
1.4	*-104*	
1.5	*-103*	
1.7	*-102*	
1.9	*-101*	
2.2	***-100***	***100 fW***
2.5	*-99*	
2.8	*-98*	
3.1	*-97*	
3.5	*-96*	
3.9	*-95*	
4.4	*-94*	
5	*-93*	
5.6	*-92*	
6.3	*-91*	
7	***-90***	***1 pW***
7.9	*-89*	
8.9	*-88*	
9.9	*-87*	
11	*-86*	
13	*-85*	
14	*-84*	
16	*-83*	
18	*-82*	
20	*-81*	
22	***-80***	***10 pW***
25	*-79*	
28	*-78*	
32	*-77*	
35	*-76*	
40	*-75*	
45	*-74*	
50	*-73*	
56	*-72*	
63	*-71*	
71	***-70***	***100 pW***
79	*-69*	
89	*-68*	
100	*-67*	
112	*-66*	
126	*-65*	
141	*-64*	
158	*-63*	
177	*-62*	
200	*-61*	
223	***-60***	***1 nW***

Vrms	dBm	Watts
224	***-60***	***1 nW***
251	*-59*	
282	*-58*	
316	*-57*	
354	*-56*	
398	*-55*	
446	*-54*	
500	*-53*	
561	*-52*	
630	*-51*	
707	***-50***	***10 nW***
793	*-49*	
890	*-48*	
1000	*-47*	
mV	***dBm***	
1.1	*-46*	
1.2	*-45*	
1.4	*-44*	
1.5	*-43*	
1.7	*-42*	
1.9	*-41*	
2.2	***-40***	***100 nW***
2.5	*-39*	
2.8	*-38*	
3.1	*-37*	
3.5	*-36*	
3.9	*-35*	
4.4	*-34*	
5	*-33*	
5.6	*-32*	
6.3	*-31*	
7	***-30***	***1 µW***
7.9	*-29*	
8.9	*-28*	
9.9	*-27*	
11	*-26*	
13	*-25*	
14	*-24*	
15	*-23*	
17	*-22*	
19	*-21*	
22	***-20***	***10 µW***
25	*-19*	
28	*-18*	
32	*-17*	
35	*-16*	
40	*-15*	
45	*-14*	
50	*-13*	
56	*-12*	
63	*-11*	
71	***-10***	***100 µW***

Vrms	dBm	Watts
71	***-10***	***100 µW***
79	*-9*	
89	*-8*	
100	*-7*	
112	*-6*	
126	*-5*	
141	*-4*	
158	*-3*	
178	*-2*	
199	*-1*	
224	***0***	***1 mW***
251	*+1*	
282	*+2*	
316	*+3*	
354	*+4*	
398	*+5*	
446	*+6*	
501	*+7*	
562	*+8*	
630	*+9*	
707	***+10***	***10 mW***
793	*+11*	
890	*+12*	
1000	*+13*	
V	***dBm***	***W***
1.1	*+14*	*0.025*
1.2	*+15*	*0.032*
1.4	*+16*	*0.04*
1.5	*+17*	*0.05*
1.7	*+18*	*0.063*
1.9	*+19*	*0.08*
2.2	***+20***	***0.1 W***
2.5	*+21*	*0.13*
2.8	*+22*	*0.16*
3.1	*+23*	*0.2*
3.5	*+24*	*0.25*
3.9	*+25*	*0.3*
4.4	*+26*	*0.4*
5	*+27*	*0.5*
5.6	*+28*	*0.63*
6.3	*+29*	*0.8*
7	***+30***	***1 W***
7.9	*+31*	*1.2*
8.9	*+32*	*1.5*
9.9	*+33*	*2*
11.2	*+34*	*2.5*
12.5	*+35*	*3.1*
14.1	*+36*	*3.9*
15.8	*+37*	*5*
17.7	*+38*	*6.3*
19.9	*+39*	*7.9*
22.3	***+40***	***10 W***

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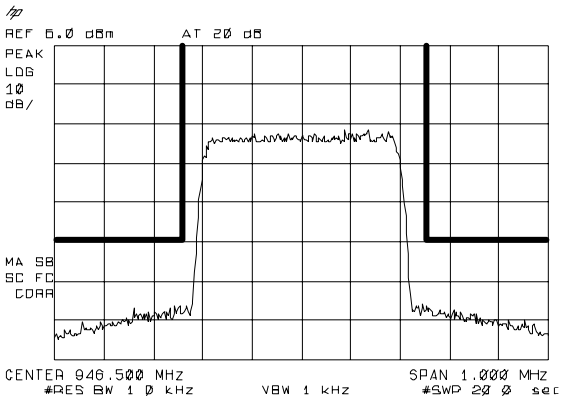
Appendix E: Spectral Emission Masks

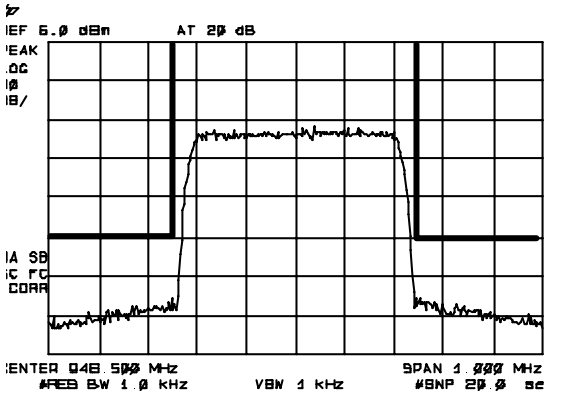
The following spectral compliance emission plots are peak power measurements at 1 watt average transmit power.

E.1 500 kHz Allocation

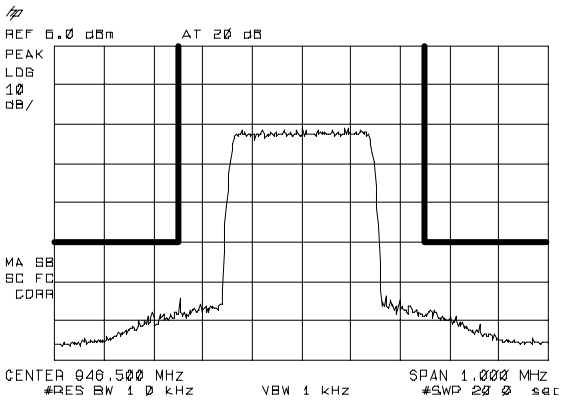
a. 1408 kbps @ 16 QAM



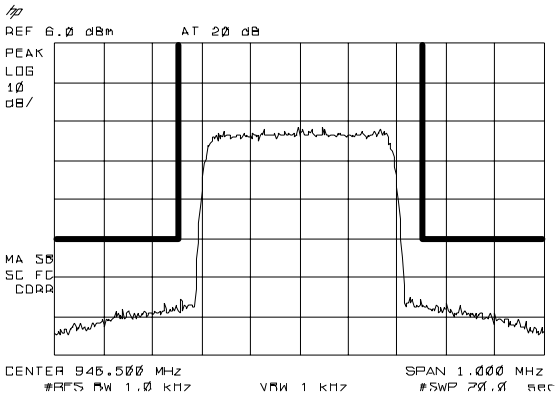
b. 1536 kbps @ 16 QAM



c. 1536 kbps @ 64 QAM

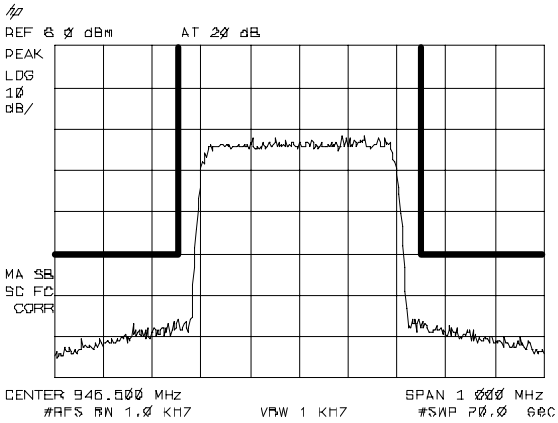


d. 2048 Kbps @ 64 QAM



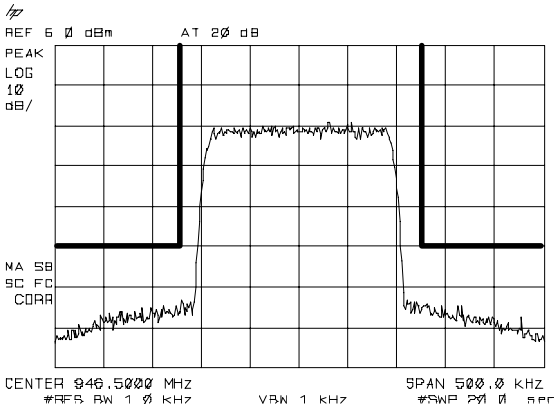
E.2 300 kHz Allocation

a. 1408 kbps @ 64 QAM



E.3 250 KHz Allocation

a. 1024 kbps @ 64 QAM



Appendix F: Redundant Backup with TP64 and TPT-2 Transfer Panels

F.1 Introduction

The Starlink SL9003Q and Digital Composite operate in a redundant hot or cold standby configuration STL link using the TP64 Transfer Panel for transmitter switching. The Starlink digital STL link may also be used in a redundant cold standby configuration with an existing analog STL as a main or backup link when using a TPT-2 Transfer Panel.

F.2 TP64 System Features

- Redundant standby system accessory for Starlink 9000 QAM STL product lines.
- Manual transfer and Master/Slave selection by front panel push button.
- Front panel tri-color LED indicators display status of transmitter and receiver functions of both Main and Standby radios.
- RF transfer relay provides high isolation, low insertion loss, and wide bandwidth, while maintaining RF termination of the Standby radio transmitter.

F.3 TP64 System Specifications

Redundant Standby System Frequency Range	0.5-2 GHz (limited by power divider)
TX Relay Frequency Range	0 to 18 GHz
TX Relay Insertion Loss	0.2 dB max. (0-4 GHz)
TX Relay Isolation	80 dB min. (0-4 GHz)
TX Relay VSWR	1.2:1 max. (0-4 GHz)
TX Relay Switching Type	Make before Break, Transfer Switch (standby TX switched into 50 ohm power termination)
TX Relay Switching Time	15 mSec max
TX Relay Life	1 × 106 cycles
TX Relay & RX Power Divider RF Connector Type	50 ohms type N (female)
RX Power Divider Insertion Loss	3.2 dB typ. f= 1GHz
Control I/O Interface	Radio A & Radio B DB-9 male (see Appendix)

Power	10 watts +12 VDC input (supplied by Main and Standby Radios) Optional External Supply 115/230 VAC
Temperature Range	Specification Performance: 0 to 50 deg C Operational: -20 to 60 deg C
Dimensions	1 RU: 17.00”w x 18.25”d x 1.718”h (43.18 x 46.36 x 4.36cm)
Shipping Weight	TBD

F.4 TP64 Installation

Normally, the TP64 is shipped with the Main and Standby transmitters per the customer order. The receiver end of the link does not require a TP64 for a redundant standby configuration.

Main/Standby Retrofit

If the TP64 is to be installed in an existing site to convert a standalone unit to a main/standby, particular attention must be made to set up all of the parameters as discussed in this manual.

STARLINK STL transmitters in a redundant standby retrofit are relatively simple to setup in the field. The system installer may want to call Moseley Technical Services for assistance.

F.4.1 TP64 Rack Installation

The TP64 Transfer Panel is normally mounted between the Main and Standby radios to allow the shortest possible lengths of transmission cable.

The TP64 is designed for mounting in standard rack cabinets. The chassis has mounting holes for Chassis Trak C-300-5-1-14 rack slides. If rack slides are used, be sure to leave at least a 15-inch service loop in all cables to the equipment.

If rack slides are not used, use the rack mounting brackets (“rack ears”) and hardware included with the TP64.

F.4.2 TP64 Power Supply

The TP64 main power (+12/+15 VDC) is supplied by the shielded RJ45 cable from both radios and therefore requires no external power connection. The Main and Standby radio supplies are summed internally in the TP64 so that if power from one radio fails, power to the TP64 will not be interrupted.

Turn on the internal supply of the TP64 by switching the rear panel power switch up. This supplies the internal electronics of the TP64. This switch should be left ON all the time.

Optionally, a wall-mount AC-DC power converter may be used for added back-up. The converter may also be useful for testing and troubleshooting. If you require an AC power converter, contact Moseley. Specify 115 Volt or 230 Volt when ordering. DC-DC converters may also be used, contact Moseley for availability.

F.5 Equipment Interconnection

F.5.1 Starlink SL9003Q Backup Operation

Transmitter

Figure F-1 shows a typical Starlink QAM (STL) Main/Standby configuration for the transmitter end of the link.

Transfer control is via the RJ45 shielded cables/RJ45-to-DB9 converters (230-12134 & 230-12127, both supplied) between NMS card “XFER” input and the respective DB9 connectors on the TP64 transfer panel.

The digital audio (AES/EBU) or analog audio lines may be split to both of the program inputs through the use of wired XLR tees. (Note: The transmitter audio encoder input impedance default is 10Kohms so paralleling the inputs with the tee is acceptable. If 600 ohm termination is preferred internal jumpers E2 & E5 must be set to 600 ohms on the audio encoder of either the main or the backup link but not both. Installing 600 ohm termination will lower the audio level by 6 dB).

The RS-232 data control aux channel can be split to both transmitters through a “modem splitter”. The splitter may be a passive device, such as Black Box p/n TLO73A-R2 (3 port, MS-3).

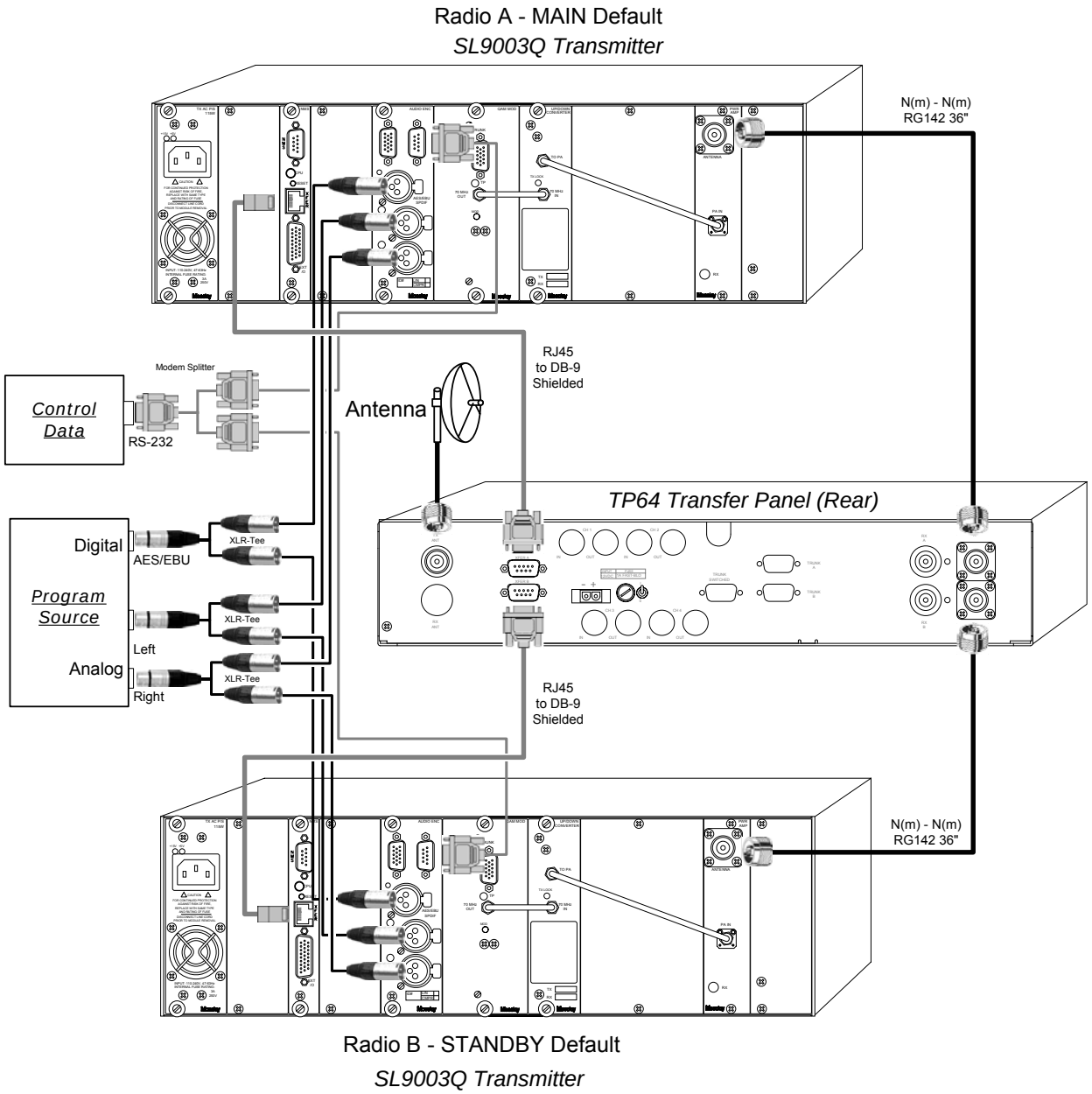


Figure 8-1 Starlink SL9003Q Transmitter Main/Standby Configuration

Receiver

Figures F-2 and F-3 show a typical Starlink QAM (STL) Main/Standby configuration for the receiver end of the link. A TP64 is not required, as both of the receivers are "ON" all the time. The antenna input is split to the two receivers with an RF power divider.

Audio Switching – with Optimod Audio Processor

The Main and Standby audio outputs can be routed to the inputs of an Orban Optimod stereo generator (with the AES/EBU input option) or similar device. Route the AES/EBU from the Main receiver and the analog from the Standby receiver, and the Optimod will always default to the AES/EBU input if the data is valid (i.e., the receiver audio data is locked).

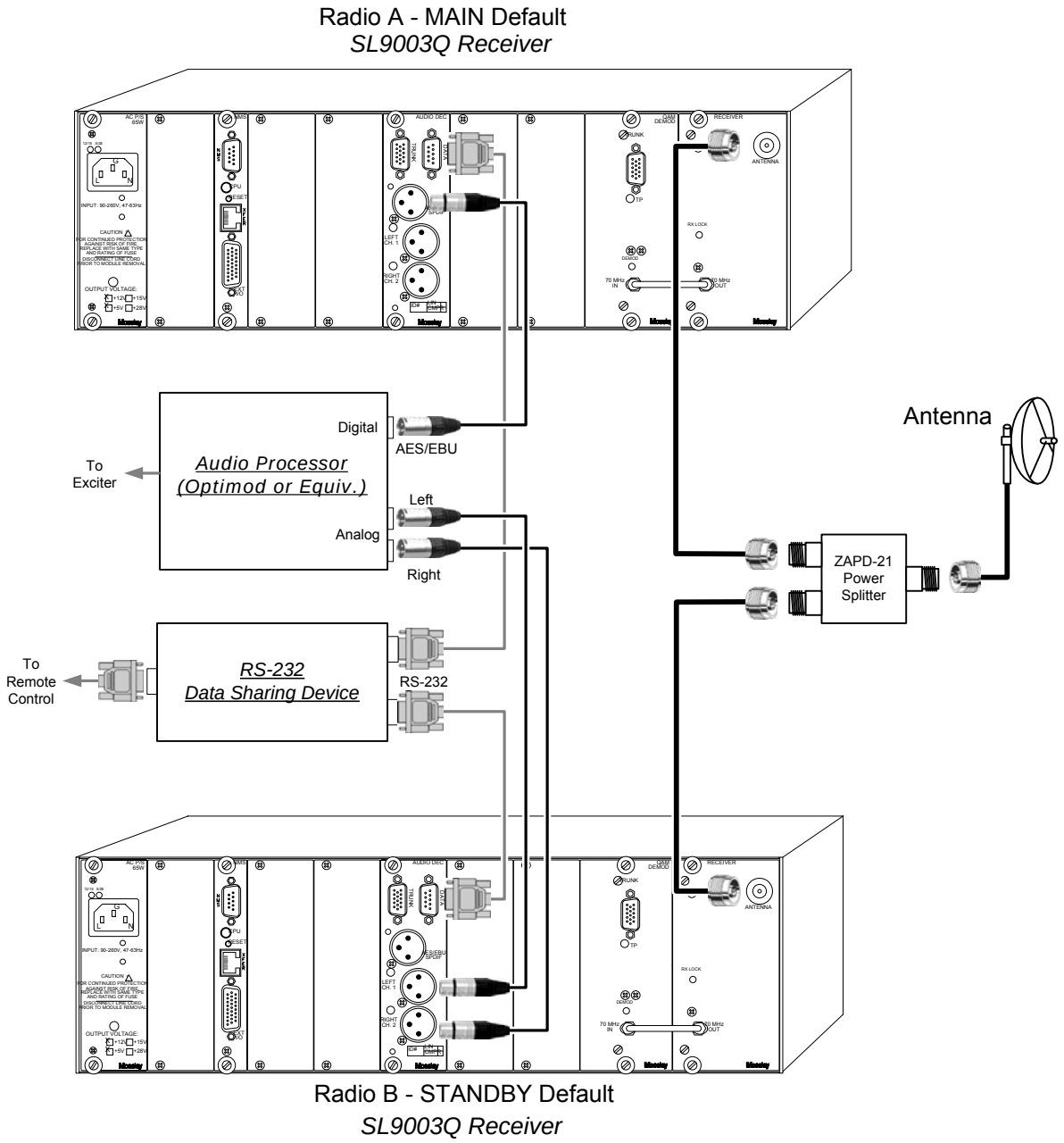


Figure 8-2 Starlink SL9003Q RX Main/Standby Connection (w/OPTIMOD)

Receiver Audio Switching - External

If there is no Optimod (or similar) stereo generator/processor at the receiver end of the link, or it is desirable to use common discrete or AES/EBU audio, an external audio switching router may be used to select the active audio feed. The Broadcast Tools SS 2.1/Terminal III switcher/router is shown below in this application (Figure F-3).

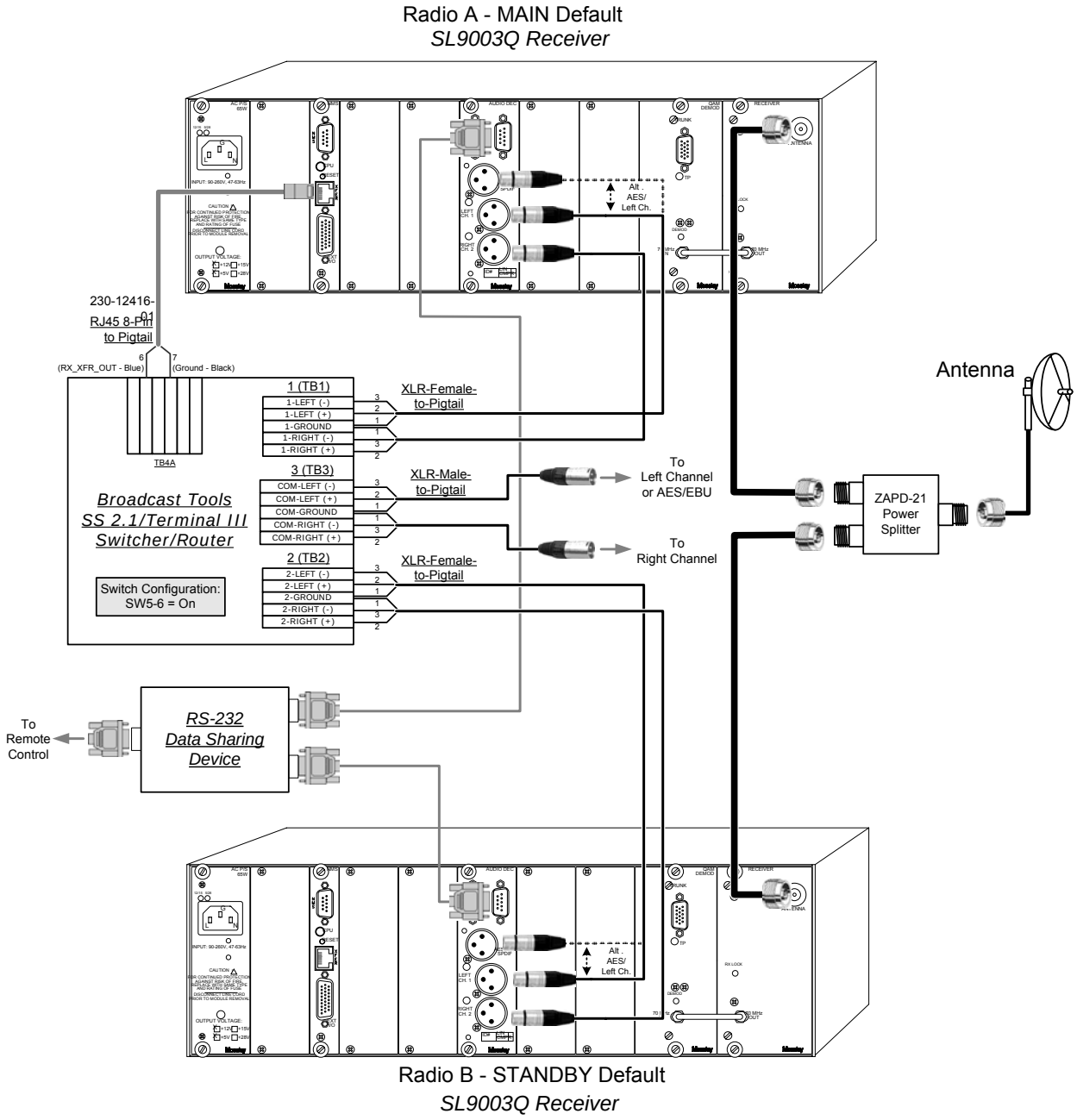


Figure 8-3 Receiver Audio Output Switching-External Control (Discrete or Digital Audio)

The router directs one of two balanced input pairs to the common balanced output. In a typical application the router is rack mounted between main and standby receivers. Figure F-3 shows the configuration for discrete audio. For digital audio outputs only, the left or right channel may be substituted with the AES/EBU channel.

The Main Receiver provides control logic from the RJ45 connector (XFER) on the NMS card for switching signal the switcher/router. The Main receiver control line (RJ45 pin 6) will be HIGH (+5V) to indicate the Main receiver is healthy and router input 1 will be selected. If the Main

GND
5
4

receiver fails, the line will go LOW, and input 2 will be selected (the Standby receiver will then be active).

The Broadcast Tools switcher router is configured internally with DIP switches to operate from external control. The lid must be removed from the router to switch the DIP Switch 5 – 6 to the ON position for remote control.

The transfer control cable is available from Moseley for this configuration (203-12416-01), although a cable can be made from a shielded RJ-45 (Black Box p/n EVNSL60-0006). This is a 6 foot cable that can be cut, and the ends tinned to provide the RX XFER OUT signal (RJ45 pin 6) for the indicated connection. Be sure to maintain the shield performance by connecting to ground. The high RF levels in typical STL receiver environments can cause problems.

F.5.2 Starlink Digital Composite Backup

Figure F-4 shows a typical Starlink Digital Composite (STL) Main/Standby configuration for the transmitter end of the link.

Transfer control is via shielded RJ45 cables and RJ45-to-DB9 converters (230-12134 & 230-12127, both supplied) between NMS card “XFER” input and the respective DB9 inputs on the TP64 transfer panel.

The composite program signal is split to both receiver composite inputs through a BNC tee.

The RS-232 data control aux channel can be split to both transmitters through a “modem splitter”. The splitter may be a passive device, such as Black Box p/n TLO73A-R2 (3 port, MS-3).

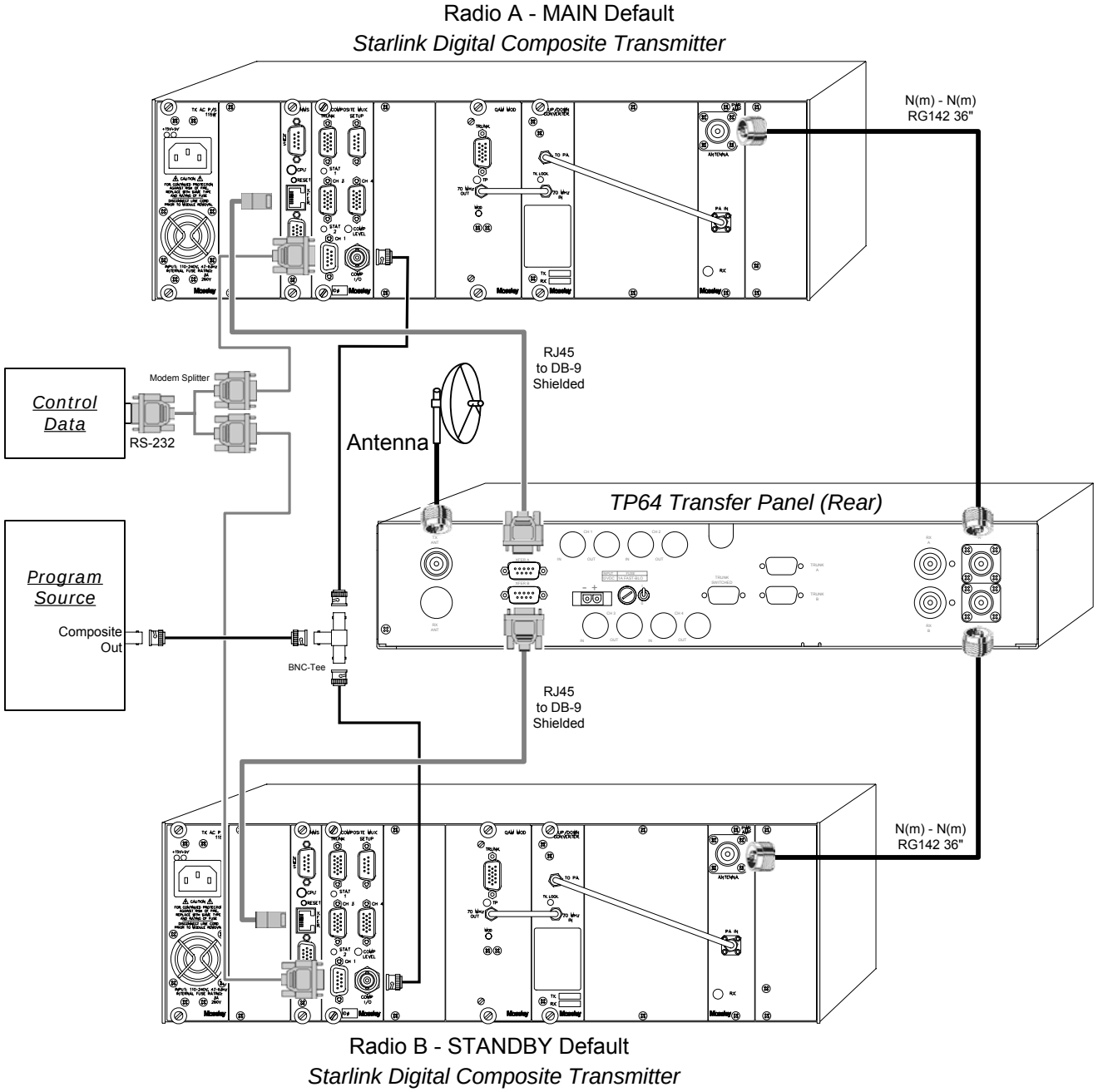


Figure 8-4 Starlink Digital Composite Transmitter Main/Standby Configuration

Receiver Composite Switching

The Starlink Digital Composite requires an external signal router to select the active composite output. The Broadcast Tools SS 2.1/BNC III switcher/router is shown in Figure F-5 performing this function. The router selects one of two unbalanced coaxial inputs. In a typical installation it is rack mounted between the main and standby receivers.

The Main Receiver provides control logic from the RJ45 connector (XFER) on the NMS card for switching signal the switcher/router. The Main receiver control line (RJ45 pin 6) will be HIGH (+5V), signifying the Main receiver to be good and router input 1 will be selected. If the Main receiver fails, the line will go LOW, and input 2 will be selected (the Standby receiver will then be active).

The Broadcast Tools switcher router is configured internally with DIP switches to operate from external control. Remove the lid from the router and switch the DIP Switch 5 – 6 to the ON position. Replace the lid.

Also the Broadcast Tools SS2.1 BNCIII switcher/router has an impedance selection jumper that must be taken into consideration. By the default the router places a 75 ohm resister in series with the common output. We suggest installing jumper JP1 which bypasses this resister and sets the impedance to 0 ohms.

The only time it may be desirable to leave this jumper out is if there is a long length of cable between the router and the exciter and frequency response (and stereo separation) are adversely affected by cable capacitance. In this case the exciter must be terminated in 75 ohms. This will lower the composite level by 6 dB which may lead to other complexities.

The transfer control cable is available from Moseley for this configuration (203-12416-01), although a cable can be made from a shielded RJ-45 (Black Box p/n EVNSL60-0006). This is a 6 foot cable that can be cut, and the ends tinned to provide the RX XFER OUT signal (RJ45 pin 6) for the indicated connection. Be sure to maintain the shield performance by connecting to ground. The high RF levels in typical STL receiver environments can cause problems.

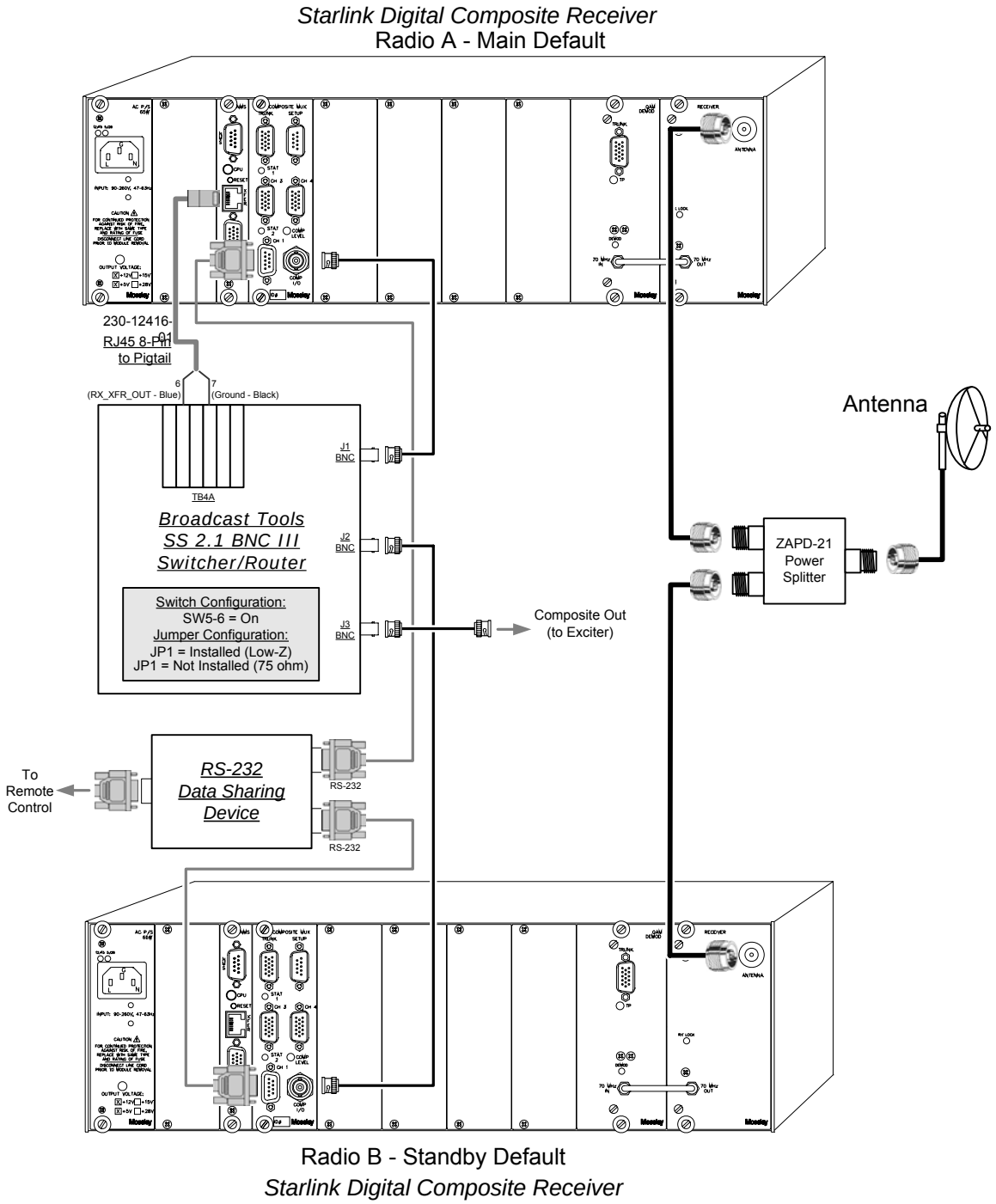


Figure 8-5 Starlink Digital Composite Receiver Main/Standby Configuration

F.5.3 Digital STL with Analog STL Backup using a TPT-2

System Considerations

Incompatible Modulation Formats

The PCL series analog STL's (or any analog STL) may be used as a backup for the Starlink with awareness of the how operational differences between the two systems effect backup operation. Specifically the two systems have incompatible rf modulation formats. The analog STL links (i.e., PCL series) use Frequency Modulation (FM) vs. Quadrature Amplitude Modulation (QAM) for the Starlink digital STL links. An FM transmitter will not work with a QAM receiver and visa versa.

What this means is the backup does not operate in the traditional redundant sense. Only one link can be active at a time, the QAM STL receiver is valid when QAM STL transmitter is selected, and analog STL receiver when the analog STL transmitter is selected.

For instance the transfer panel will switch to a back-up transmitter when a failure mode is detected in the main transmitter. If the Starlink transmitter is selected as main and fails then the Starlink receiver will automatically switch over to the analog backup receiver when it fails to decode the analog transmission from the PCL6000 or 606.

But if a receiver fails (at the receiver end), the back-up receiver will not be able to take over until the transmitters are forced to switch to the compatible unit. In this case the transmitter switchover can be accomplished through the use of a return telemetry signal via remote control, which detects the failed receiver and sends back a control line to transfer at the studio site.

Composite vs. Discrete Audio

The other issue is most typical PCL6000/606 links are set for composite FM transmission. The Starlink SL9003Q is a discrete audio link and does not support this type of composite baseband. The Starlink Digital Composite STL must be used if intended to operate as a backup with a composite analog system.

Alternatively a PCL6000/606 composite STL system may be made compatible with a Starlink SL9003Q Discrete Audio STL if it is first converted to a discrete digital system through the use of a DSP6000. This will provide the discrete audio (left/right or digital AES) necessary for switchover.

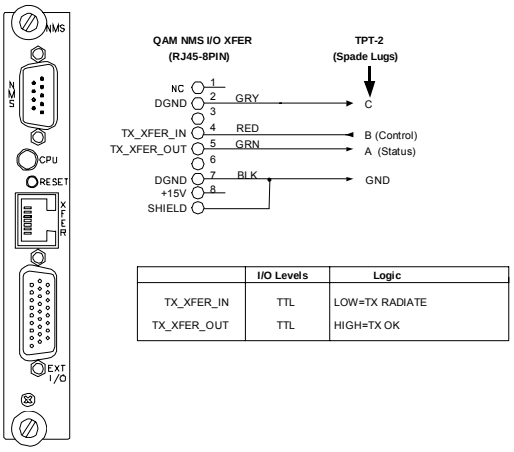
Using a TPT-2 Transfer Panel

The TPT-2 has the appropriate logic to work properly with the PCL series STL transmitters. We therefore recommend using a TPT-2 transfer panel when using the PCL series analog STLs rather than the TP64 transfer panel for the hybrid analog/digital backups that will be discussed.

Using a Starlink with TPT-2

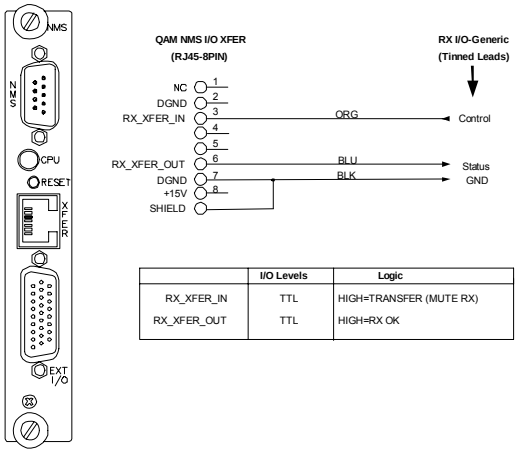
Figure F-6 gives the details for Starlink NMS wiring to the TPT-2 for the transmitter and external switching for the receiver. Starlink-to-TPT2 interconnection cables are available from Moseley; part numbers 230-12225-01 for the transmitter and 230-12416-01 for the receiver.

Transmitter NMS



	I/O Levels	Logic
TX_XFER_IN	TTL	LOW=TX RADIATE
TX_XFER_OUT	TTL	HIGH=TX OK

Receiver NMS



	I/O Levels	Logic
RX_XFER_IN	TTL	HIGH=TRANSFER (MUTE RX)
RX_XFER_OUT	TTL	HIGH=RX OK

Figure 8-6 Starlink TX & RX NMS-Transfer I/O Connection

For use with the TPT-2 the Starlink transmitter NMS card requires modification for compatible logic levels. Remove the NMS card. Install a 10 kohms resistor for R33. On Jumper E4 select 12V. This entails cutting the trace between pins 1 & 2 and wiring between pins 2 & 3 on E4.

Transmitter

Figure F-7 shows a typical Starlink Digital Composite (STL) Main/Standby configuration using a PCL series analog composite STL as backup.

In using the TPT-2 for this hybrid digital/analog backup configuration the logic is such that the PCL series STL must be connected to TRANSMITTER A as shown below in Figure F-7. The TPT-2 allows the user to select either Transmitter A or Transmitter B as the Main Transmitter. Select Transmitter B as Main and Transmitter A as Backup to select the Starlink as the main link.

Set the Starlink system to operate in Cold-Standby mode. In this mode the transmitter is not radiating unless selected to correspond to the TPT-2 operation.

The Starlink-to-TPT-2 transfer control cable is available from Moseley for this configuration (203-12225-01), although a cable can be made from a shielded RJ-45 (Black Box p/n EVNSL60-0006). This is a 6 foot cable that can be cut, and the ends tinned to provide the signals for the indicated connection. Be sure to maintain the shield performance by connecting to ground. The high RF levels in typical STL receiver environments can cause problems.

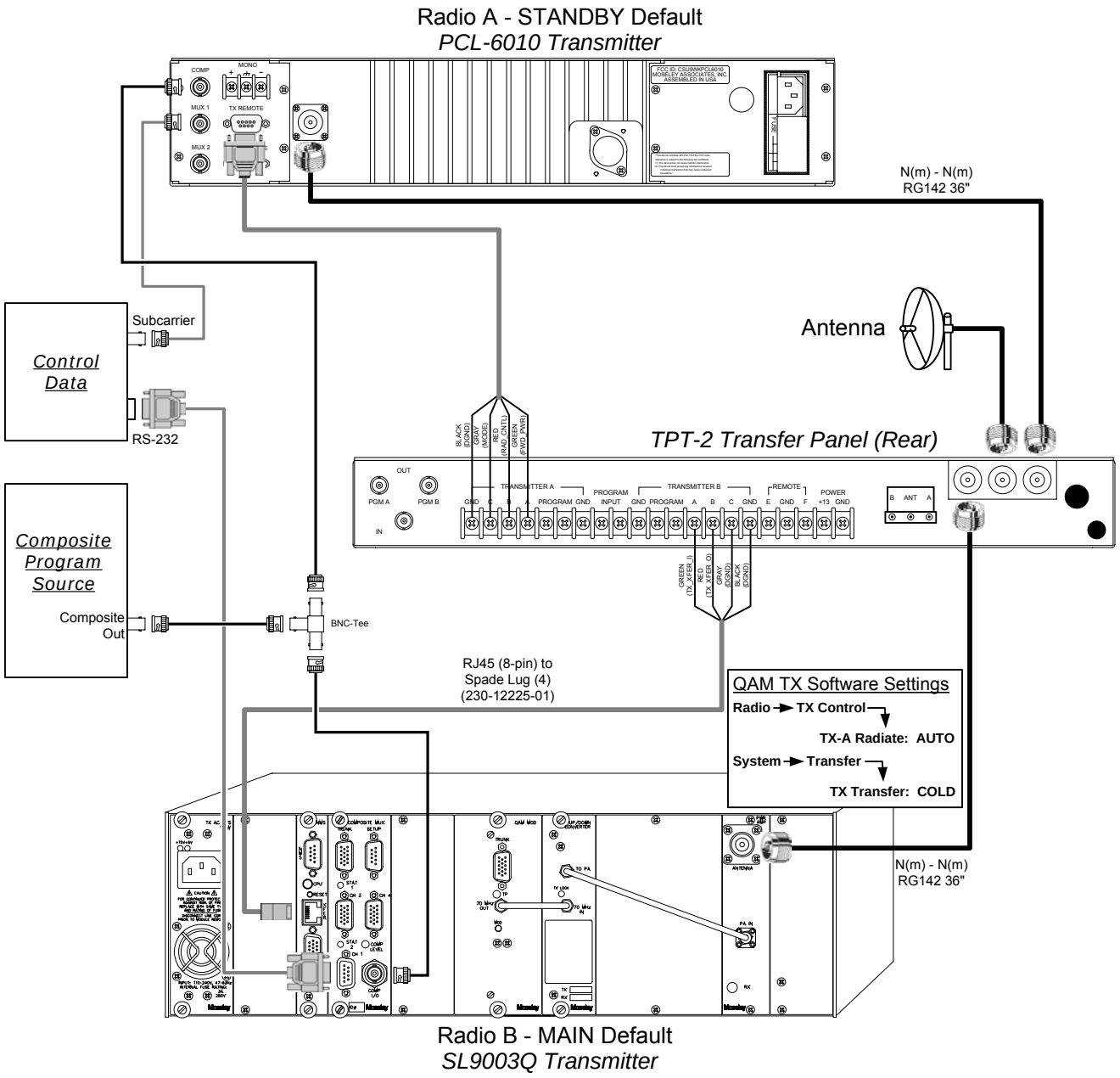


Figure 8-7 Starlink Digital Composite with PCL Series TX Backup

Receiver

Figure F-8 shows a typical Starlink Digital Composite (STL) Main/Standby configuration using a PCL series analog composite STL as a backup.

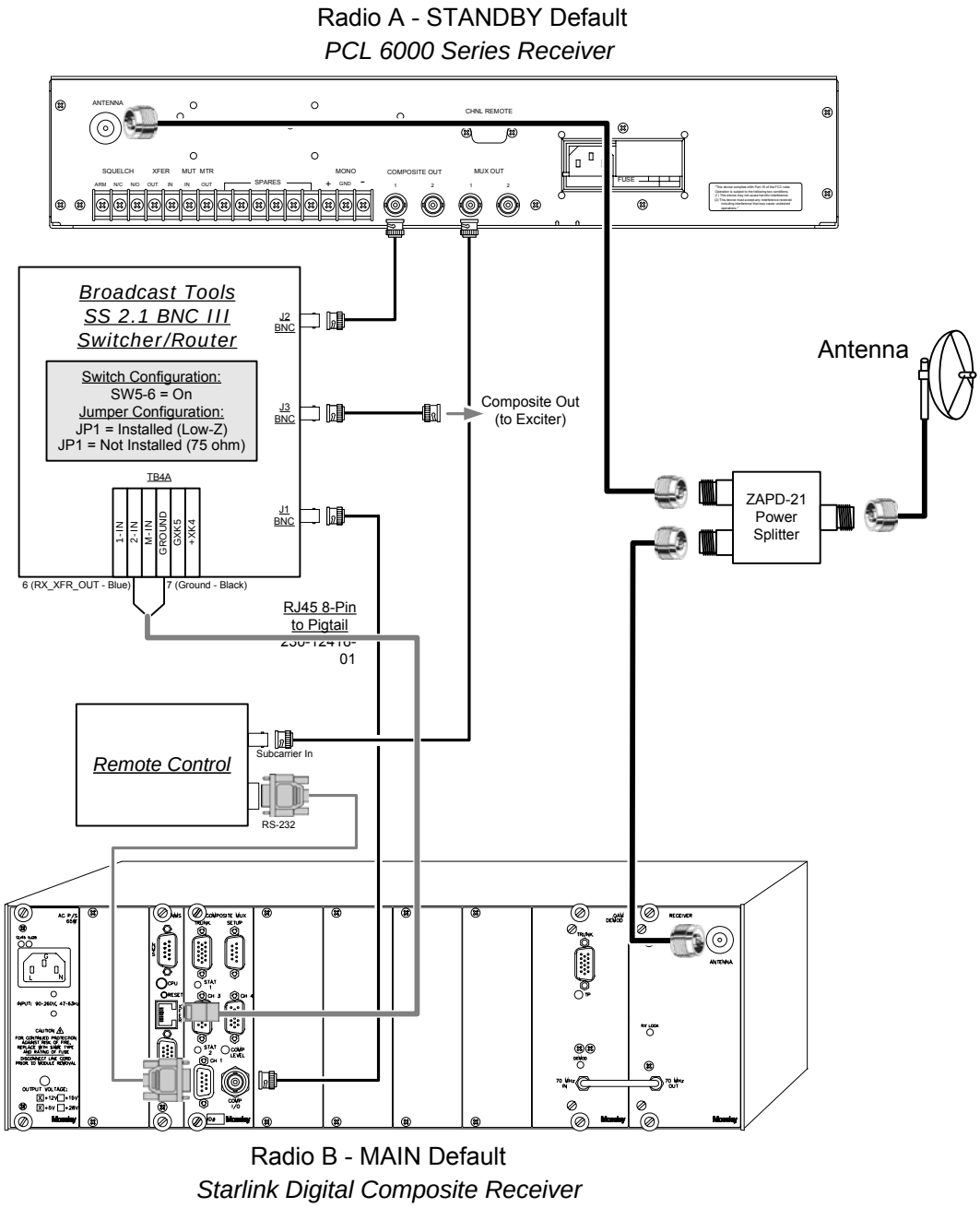


Figure 8-8 Starlink Digital Composite RX and PCL Series RX Backup

Receiver Composite Switching

The redundant (backup) composite scenario require an external signal router to select the active composite output. The Broadcast Tools SS 2.1/BNC III switcher/router is shown in Figure F-8 (above) performing this function. The router selects one of two unbalanced coaxial inputs. In a typical installation it is rack mounted between the main and standby receivers.

The Main Receiver provides control logic from the RJ45 connector (XFER) on the NMS card for switching signal the switcher/router. The Main receiver control line (RJ45 pin 6) will be HIGH (+5V), signifying the Main receiver to be good and router input 1 will be selected. If the Main receiver fails, the line will go LOW, and input 2 will be selected (the Standby receiver will then be active).

The Broadcast Tools switcher router is configured internally with DIP switches to operate from external control. Remove the lid from the router and switch the DIP Switch 5 – 6 to the ON position. Replace the lid.

Also the Broadcast Tools SS2.1 BNCIII switcher/router has an impedance selection jumper that must be taken into consideration. By the default the router places a 75 ohm resister in series with the common output. Install jumper JP1 which bypasses this resister and sets the impedance to 0 ohms.

(The only time it may be desirable to leave this jumper out is if there is a long length of cable between the router and the exciter and frequency response (and stereo separation) are adversely affected by cable capacitance. In this case the exciter must be terminated in 75 ohms. This will lower the composite level by 6 dB which may lead to other complexities).

The transfer control cable is available from Moseley for this configuration (203-12416-01), although a cable can be made from a shielded RJ-45 (Black Box p/n EVNSL60-0006). This is a 6 foot cable that can be cut, and the ends tinned to provide the RX XFER OUT signal (RJ45 pin 6) for the indicated connection. Be sure to maintain the shield performance by connecting to ground. The high RF levels in typical STL receiver environments can cause problems.

F.5.4 Discrete Starlink with DSP6000 Backup using a TPT-2

Transmitter

Figure F-9 shows a typical Starlink SLS9003Q (STL) Main/Standby configuration using a DSP6000/PCL series analog STL as backup.

The digital audio (AES/EBU) or analog audio lines may be split to both of the program inputs through the use of wired XLR tees. (Note: The transmitter audio encoder input impedance default is 10Kohms so paralleling the inputs with the tee is acceptable. If 600 ohm termination is preferred internal jumpers E2 & E5 must be set to 600 ohms on the audio encoder of either the main or the backup link but not both. Installing 600 ohm termination will lower the audio level by 6 dB).

The RS-232 data control aux channel can be split to both transmitters through a “modem splitter”. The splitter may be a passive device, such as Black Box p/n TLO73A-R2 (3 port, MS-3).

In using the TPT-2 for this hybrid digital/analog backup configuration the logic is such that the PCL series STL must be connected to TRANSMITTER A as shown below in Figure F-6. The

TPT-2 allows the user to select either Transmitter A or Transmitter B as the Main Transmitter. Select Transmitter B as Main and Transmitter A as Backup to select the Starlink as the main link.

Set the Starlink system to operate in Cold-Standby mode. In this mode the transmitter is not radiating unless selected to correspond to the TPT-2 operation.

The Starlink-to-TPT-2 transfer control cable is available from Moseley for this configuration (203-12225-01), although a cable can be made from a shielded RJ-45 (Black Box p/n EVNSL60-0006). This is a 6 foot cable that can be cut, and the ends tinned to provide the signals for the indicated connection. Be sure to maintain the shield performance by connecting to ground. The high RF levels in typical STL receiver environments can cause problems

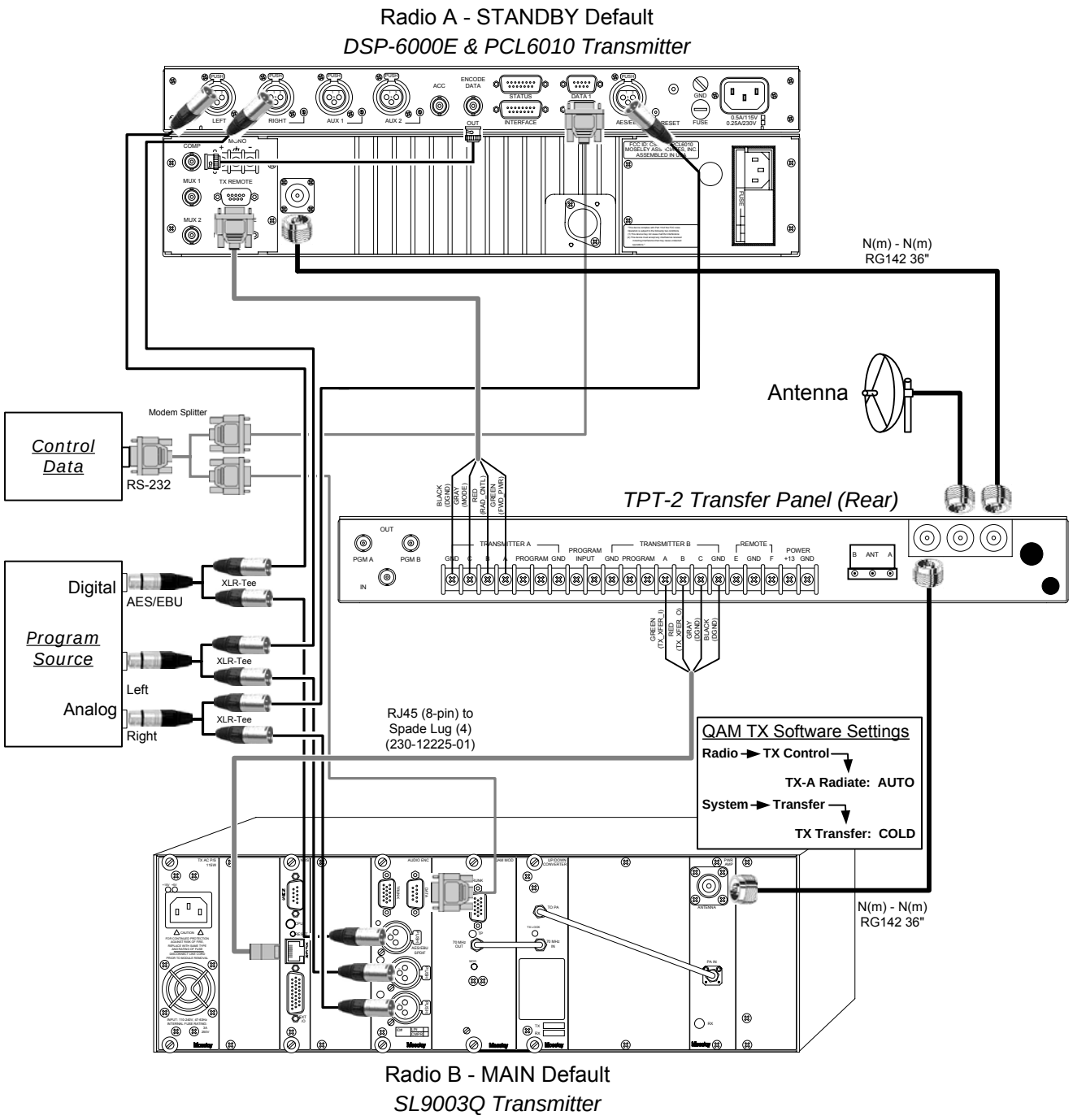


Figure 8-9 Starlink QAM TX with DSP/PCL TX Backup and TPT-2 Connection

Receiver

Figures F-10 and F-11 show a typical Starlink QAM (STL) Main/Standby with DSP/PCL as backup configuration for the receiver end of the link. A TPT-2 is not required, as both of the receivers are "ON" all the time. The antenna input is split to the two receivers with an RF power divider.

Receiver Audio Switching – with Optimod Audio Processor

The Main and Standby audio outputs can be routed to the inputs of an Orban Optimod stereo generator (with the AES/EBU input option) or similar device. Route the AES/EBU from the Main receiver and the analog from the Standby receiver, and the Optimod will always default to the AES/EBU input if the data is valid (i.e., the receiver audio data is locked).

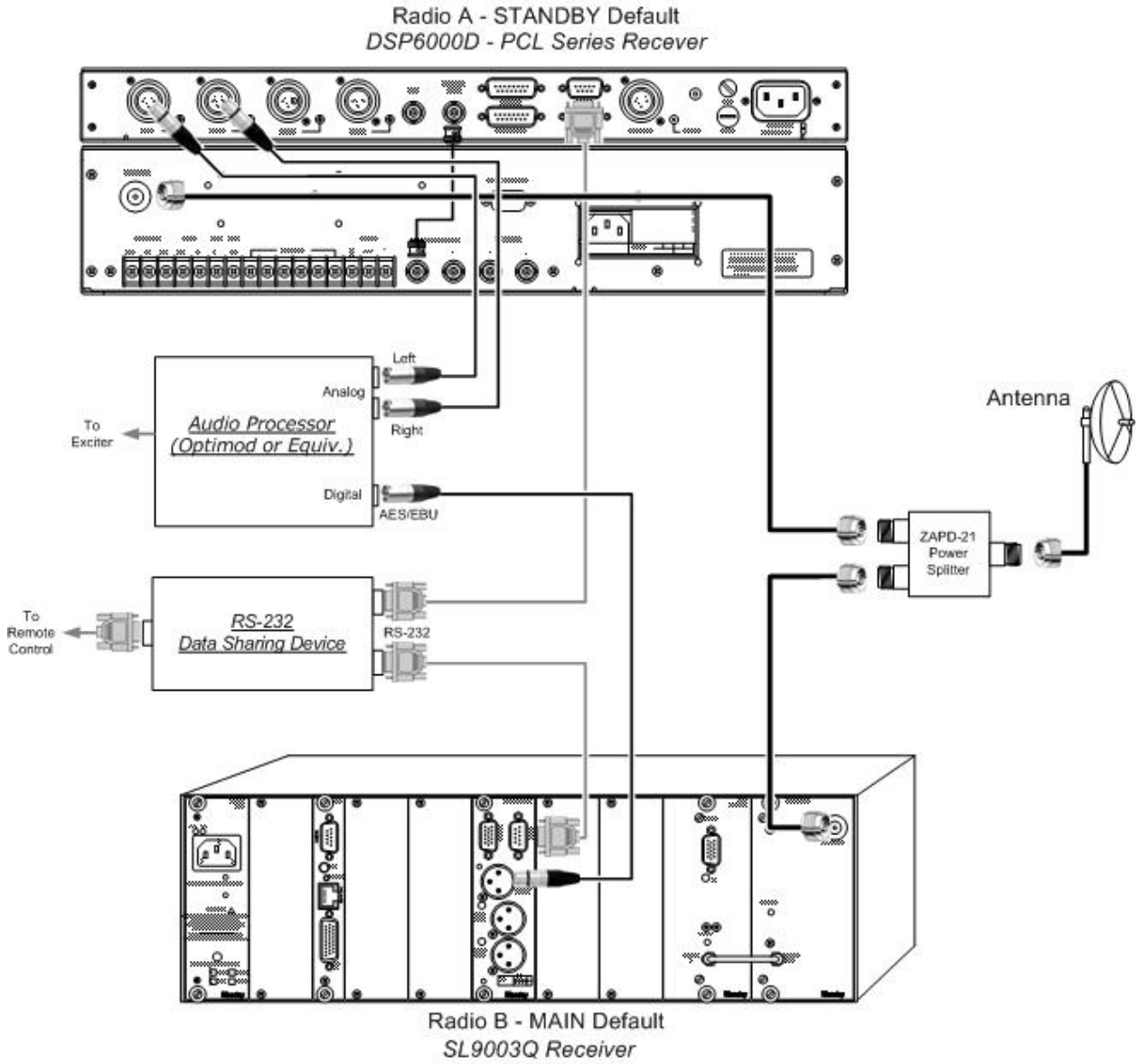


Figure 8-10 Starlink QAM RX with DSP/PCL RX Backup and Optimod Connection

Receiver Audio Switching - External

If there is no Optimod (or similar) stereo generator/processor at the receiver end of the link, or it is desirable to use common discrete or AES/EBU audio, an external audio switching router may be used to select the active audio feed. The Broadcast Tools SS 2.1/Terminal III switcher/router is shown below in this application (Figure F-11).

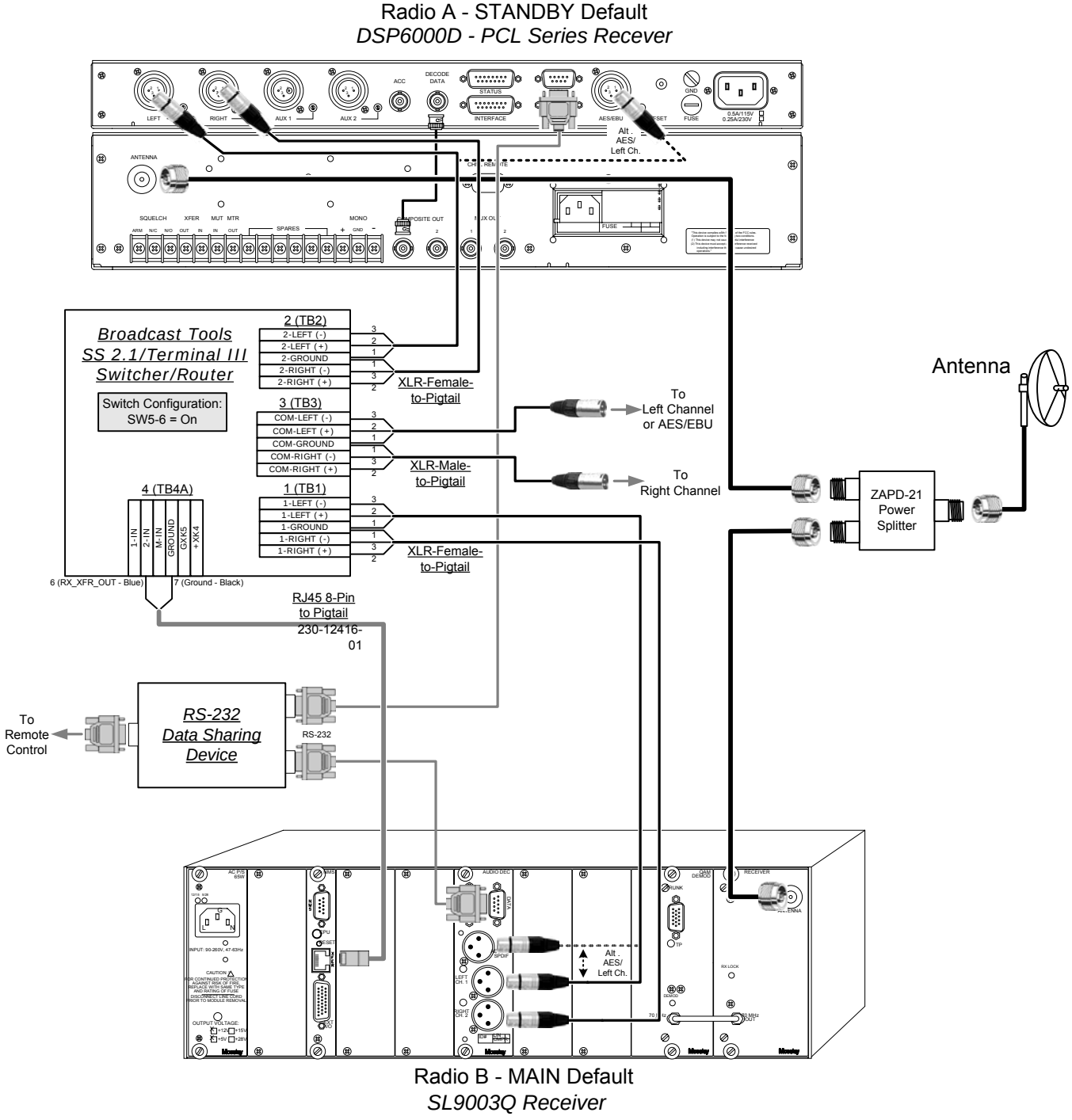


Figure 8-11 Starlink QAM RX with DSP/PCL RX Backup and Router Connection

The router directs one of two balanced input pairs to the common balanced output. In a typical application the router is rack mounted between main and standby receivers. Figure F-11 shows the configuration for discrete audio. For digital audio outputs only, the left or right channel may be substituted with the AES/EBU channel.

The Starlink Receiver acting as the main receiver provides control logic from the RJ45 connector (XFER) on the NMS card for switching signal the switcher/router. The Starlink receiver control line (RJ45 pin 6) will be HIGH (+5V) to indicate the main receiver is healthy and router input 1 will be selected. If the main receiver fails, the line will go LOW, and input 2 will be selected (the Standby receiver will then be active).

The Broadcast Tools switcher router is configured internally with DIP switches to operate from external control. The lid must be removed from the router to switch the DIP Switch 5 – 6 to the ON position for remote control.

The transfer control cable is available from Moseley for this configuration (203-12416-01), although a cable can be made from a shielded RJ-45 (Black Box p/n EVNSL60-0006). This is a 6 foot cable that can be cut, and the ends tinned to provide the RX XFER OUT signal (RJ45 pin 6) for the indicated connection. Be sure to maintain the shield performance by connecting to ground. The high RF levels in typical STL receiver environments can cause problems.

F.6 Operation

F.6.1 Hot/Cold Standby Modes

Hot Standby (*preferred)

Hot standby leaves both transmitters in the RADIATE ON condition, and the TP64 controls the RF relay to select the active transmitter, thereby decreasing switchover time. This is the preferred operating mode.

Cold Standby

Cold standby can be used in situations where low power consumption is a priority. In this mode, the TP64 will control the RADIATE function of each transmitter, turning the RF output ON (in tandem with the RF relay) as required for switching. This will increase switching time and a corresponding increase in data loss during the switchover.

F.6.2 TP64 Front Panel Controls and Indicators

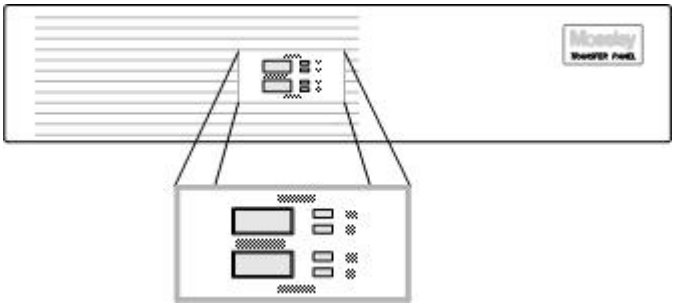


Figure 8-12 TP64 Front Panel

LED Indicators

Green: The indicated module is active, and that the module is performing within its specified limits.

Yellow: The indicated module is in standby mode, ready and able for back-up transfer.

Red: There is a fault with the corresponding module. It is not ready for backup, and the TP64 will not transfer to that module.

TRANSFER Switches

The RADIO A and RADIO B transfer switches cause the selected radio to become active, and the Master. See the following section for further details.

F.6.3 Master/Slave Operation & LED Status

The TP64 operates in a Master/Slave logic mode. In the power up condition, the Master is RADIO A. This means that RADIO A is the default active unit. The following logic applies to hot or cold standby, external or internal duplexer configurations.

Table 8-8 TP64 Transmitter Master/Slave Logic

	Selected Master	TXA Status	TXB Status	TXA LED	TXB LED	Active TX	TX Relay Position
A-Master Logic	A	OK	OK	GRN	YEL	A	A
	A	OK	FAIL	GRN	RED	A	A
	A	FAIL	OK	RED	GRN	B	B
	A	FAIL	FAIL	RED	RED	N/A	A
B-Master Logic	B	OK	OK	YEL	GRN	B	B
	B	OK	FAIL	GRN	RED	A	A
	B	FAIL	OK	RED	GRN	B	B
	B	FAIL	FAIL	RED	RED	N/A	B

Table 8-9 TP64 Receiver Master/Slave Logic

	Selected Master	RXA Status	RXB Status	RXA LED	RXB LED	Active RX	RX Data & Clk
A-Master Logic	A	OK	OK	GRN	YEL	A	A
	A	OK	FAIL	GRN	RED	A	A
	A	FAIL	OK	RED	GRN	B	B
	A	FAIL	FAIL	RED	RED	N/A	None
B-Master Logic	B	OK	OK	YEL	GRN	B	B
	B	OK	FAIL	GRN	RED	A	A
	B	FAIL	OK	RED	GRN	B	B
	B	FAIL	FAIL	RED	RED	N/A	None

A-Master Logic (default power-up):

If RADIO A is “good”, the TP64 will remain in RADIO A position, regardless of RADIO B’s status.

If RADIO A fails, the TP64 will switch to RADIO B (assuming that RADIO B is “good”)

If RADIO A then returns to a “good” condition, the TP64 will switch back to RADIO A (the default Master)

Manual Switchover to B-Master Logic

The front panel switch on the TP64 can be used to manually force the system to a new Master.

By pressing the RADIO B button, RADIO B now becomes the Master, and the TP64 will switchover to RADIO B (assuming that RADIO B is “good”).

The default A-Master Logic will then switch to B-Master Logic, as outlined in Tables F-1 and F-2.

Note: Manual switching of the Master is often used to force the system over to the standby unit. The user may want to put more “time” on the standby unit after an extended period of service.

In Hot Standby configurations, this will not buy the user anything in terms of reliability. In a Cold Standby, the “burn time“ is more significant, since the RF power amplifier device operating life becomes a factor.

F.7 Software Settings

The full array of available settings for the Control and Configuration menus are located in QAM User Manual. Shown here are the applicable settings for redundant standby systems.

F.7.1 Starlink Transmitter Settings

These settings configure the transmitter for hot (or cold) standby.

It is important that each Starlink transmitter in the redundant pair is configured identically for proper operation.

Controls #1

TX CONTROL:

XFER: Configures the unit for HOT or COLD STANDBY operation, depending on the setting of TX XFER (next line in menu).

TX XFER: **(select per system requirement)**

HOT: Configures the unit for HOT STANDBY operation.*(preferred)

COLD: Configures the unit for COLD STANDBY operation.

TX STATUS: **(shown in this menu for ease of use)**

RADIATE: Indicates the transmitter is ON and radiating

OFF: Indicates the transmitter is OFF

F.7.2 TP64 Settings

The TP64 software settings are contained in the internal firmware. Aside from the front panel RADIO A/B Master Select (as described above), there are no user-configurable settings in the TP64 unit.

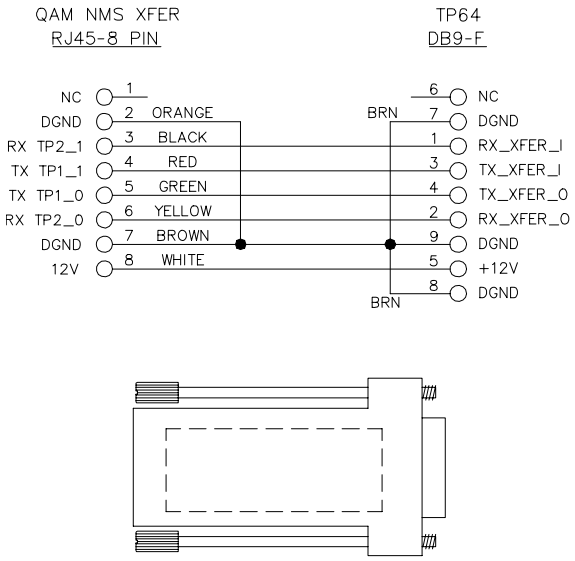


Figure 8-13 STARLINK – TP64 Control Cable Adaptor 230-12127-01

Appendix G: Optimizing Radio Performance For Hostile Environments

INTRODUCTION

When shipped from the factory the SL 9003Q defaults are optimized for high-sensitivity, high spectral efficiency, and low-delay. But hostile RF environments with nearby paging transmitters, strong co-channel and adjacent channel interference sources, lightening, and unlicensed ISM band may require a more aggressive configuration.

The SL9003Q continues in Moseley's reputation for robust radio products that handle difficult environments. The SL9003Q can be configured for optimal performance from the benign to the most brutal environments directly from the front panel. The following discussion will show the user how to configure the frequency, front-end attenuator, QAM mode, interleaver, and pre-selector for best results and tradeoffs that result.

FRONT-END ATTENUATOR

The first place to start is with the front-end attenuator. The receiver has a 20 dB variable pin-diode attenuator in front of the pre-amp to protect the receiver from overload when faced with strong in-band and out-of-band undesired signals that find their way past the pre-selector filter. This attenuator is controlled from the front panel under QAM RADIO –> RX CONTROL to one of three modes, ON/ OFF/ AUTO.

> **AUTO:** (Factory default) In this mode the front-end attenuation is controlled by a leveling loop that begins to insert attenuation in front of the pre-amp when the input signal exceeds –28 dBm. It continues to increase attenuation with increasing input signal up to –8 dBm. In general this mode insures that your receiver will operate with greatest sensitivity and yet provide protection against occasional interfering signals.
>
> **OFF:** This mode disables the attenuator completely. Use this mode if strong bursty interfering signals are sporadically triggering the attenuator leveling control and causing errors (this is a fairly low likelihood).
>
> **ON:** This mode forces the attenuator on essentially placing a 20 dB pad in front of the pre-amp. This mode provides the greatest continuous protection against interference but also eats up 20 dB of threshold and fade margin. Use this mode if your received signal exceeds –43 dBm or when strong continuous interferer(s) existing in-band cause bit errors.

It should be emphasized that it is not necessarily only high-level adjacent channels that cause interference. There are many combinations of signals that can give rise to intermodulation distortion, which cause the resultant product to fall within the desired passband.

ASSESSING INTERFERENCE

This method is very useful to assess interference at your STL receiver (especially if you do not have a spectrum analyzer available).

Turn OFF the STL transmitter at the studio. At the receiver from the front panel navigate to QAM RADIO –> MODEM -> STATUS. The first line entry "QAM Modem" will indicate the RSL (Received Signal Level) in dBm. With no interference present the RSL will be below –120 dBm, typically. If this is not the case and RSL is above this level then you are receiving undesired interference within your STL passband.

For the QAM data to be properly demodulated at the STL receiver the RSL must be greater than the interference noise floor by the following amounts:

21 dB for 16 QAM
24 dB for 32 QAM
27 dB for 64 QAM

(To determine your QAM mode navigate down 5 more menus under MODEM STATUS until you read "MODE".) For instance, if your STL is operating in 32 QAM mode (i.e., 32Q) and your RSL interference is –90 dBm, then the minimum signal that your STL receiver can acquire must be greater than –66 dBm. Add 10 dB more for fade margin then you will want to see an RSL of at least -56 dBm.

INTERLEAVER

Bit errors may also result from sources other than traditional RF interference and Gaussian noise from low signal levels. Some of these noise sources include microphonics, lightening bursts, ignition noise, and other sources that are basically bursty in its nature. The problem with bursty noise is it creates large groups of burst errors piled together, which may be too much for the Reed-Soloman error correction algorithm to correct within a single coded block of data.

To combat this phenomenon an interleaver within the QAM modem is used to spread out the error bursts over several coded blocks of data. The larger the interleaver factor the longer the errors are spread out and therefore fewer errors will occur in any coded block for any single error burst. This allows the error correction algorithm to operate on smaller number of errors within each block.

The trade off here for increasing interleaving is added delay. Table G-1 shows the correlation between interleave setting and delay.

Table 8-10 Interleave Setting vs. Delay

Interleave	Delay* (ms)
1	2.6
2	3.7
3	5
4	6
6	8
12	14

* delay is for 1408 kbps data rate

To change interleave length navigate to QAM RADIO – CONFIGURE MODEM – Intrlv. The factory setting is 3 (5 ms). Just like with the QAM mode setting the user must change the interleave setting to match on both transmitter and receiver or the system will not operate.

PRE- & POST- BIT ERROR RATE MENU

The receiver BER status screen is the most important indicator to the health of the link. From the front panel navigate to QAM RADIO – MODEM STATUS. The first screen that is shown is the "BER POST" and RSL status. "Post" refers to post-error correction count, or the bit-error-rate after Reed-Soloman error correction. This is the actual error rate. It is a long-term error count which reflects every error that has been accumulated since the last time it was reset by pressing ENTER on the front-panel. The system should be error free (displayed as 0.00E+0) under normal operating conditions but it is quite reasonable to expect occasional due to external or environmental conditions. For a healthy link the error rate should not drop below 1.0E-10 (about 1 error in 1 hours).

Navigate down one more screen to find "BER Pre". This is the pre-corrected error rate, or the error count before error correction has been applied. There will usually be some non-zero error rate before error correction due to errors caused by non-linearities within the radio link itself. This is especially true for 64 QAM modulation, which is quite sensitive to amplifier linearity and amplitude and group delay variations. The 16 QAM modulation isn't nearly so sensitive. Pre-BER is a good indicator of proper circuit operation such as whether the power amplifier is being driven too hard. An increase of only 1 dB above the factory-calibrated level can be enough to cause a substantial pre-corrected error increase. For this reason the power amplifier output level is accurately controlled and compensated over temperature.

CHANGING FREQUENCY

For some types of interference, such as strong co-channel and adjacent channel signals, the only remedy may be to move the carrier frequency away from the interference. This is also a good test to see where the interference lays.

The frequency is changed from the front panel. Refer to Sections 5.6.1 and 5.6.2 within Module Configuration, for details on programming the transmitter and receiver frequencies, respectively.

QAM RATE

If you have found interference within your passband but you can't change frequency, and you can't install larger antennae, then there is still another possibility that may help.

Lowering QAM mode will increase the receiver's resistance to co-channel interference. The lower QAM modes are more robust than the higher mode but at the expense of increased bandwidth. For instance changing from 64 QAM to 16 QAM will improve sensitivity and co-channel resiliency by 6 dB but will increase occupied spectrum by 33%. In general 16 QAM is more robust against interference, microphonics, and impulse noise such as lightning.

To change QAM rate navigate to QAM RADIO –> CONFIGURE MODEM –> Mode/Effic. Switch from 64Q/6 to 32Q/5 or to 16Q/4. It is imperative to match the QAM mode on both transmitter and receiver or the system will not operate. Don't forget to change both.

Note: When shipped from the manufacturer, the QAM mode is selected for optimal channel utilization for the particular data rate that the link is using. Changing the transmission bandwidth is left to the users discretion; exercise caution not to exceed Part 74 bandwidth allocation.

FRONT-END BANDPASS CONSIDERATIONS

The pre-selector filter that is shipped with the SL9003Q is a 5-pole inter-digital waveguide bandpass filter. It has been optimize for lowest loss, high ultimate selectivity, and reasonable cost. The bandpass is 20 MHz, which was designed to keep the loss consistent between the inside and outside channel allocations. For most applications this pre-selector should provide the best overall performance. But for extremely powerful near band interference such as pagers this pre-selector may not provide adequate protection.

Moseley has a wealth of experience in specifying filters for resolving these types of interference problem and can offer certain bandpass filters with high adjacent channel selectivity from stock. Contact the broadcast sales manager for further details.

Appendix H: FCC APPLICATIONS INFORMATION - FCC Form 601

The Moseley line of broadcast microwave links is FCC type verified for use in licensed Part 74 and Part 101bands. It is the operator's responsibility to acquire proper authorization prior to radio operation. This is accomplished by submitting FCC 601 Main Form and Form 601 Schedule I.

The main form is 103 pages. However for the Microwave Broadcast Auxiliary Service, only the following sections apply:

Form 601 Instructions (22 pages)

Main From 601 (4 pages)

Schedule I Instructions (18 pages)

Schedule I Form with supplements (5 pages)

Form FCC 601, Schedule I, is a supplementary schedule for use with the FCC Application for Wireless Telecommunications Bureau Radio Service Authorization, FCC 601 Main Form. This schedule is used to apply for an authorization to operate a radio station in the Fixed Microwave and Microwave Broadcast Auxiliary Services, as defined in 47 CFR, Parts 101 and 74.The FCC 601 Main Form must be filed in conjunction with this schedule. The forms may be found online:

FCC 601 Main Form

http://www.fcc.gov/Forms/Form601/601.pdf

FCC 601 Schedule I Form for Fixed Microwave and Microwave Broadcast Auxiliary Services

http://www.fcc.gov/Forms/Form601/601i.pdf

The data that follows is intended to assist the user in completing the required information in Form 601, Schedule I, Supplement 4 where the radio-specific information is required.

Starlink SL9003Q & Digital Composite - 950 MHz Band

The Starlink SL9003Q and Digital Composite operate as Studio-Transmitter Links (STL) in the Part 74 frequency band of 944-952 MHz.

Form 601, Schedule I, Supplement 4 Information:

Item	Description	Entry for FCC 601 Sched. I, Supp. 4
4	Lower or Center Frequency (MHz)	Enter the assigned frequency in (MHz)
5	Upper Frequency (MHz)	Not Applicable
6	Frequency Tolerance (%)	.0001%
7	Effective Isotropic Radiated Power (dBm)	(+31 dBm + Tx ant. gain – Tx cable loss + 2.15)
8	Emission Designator	500KD7W
9	Digital Modulation Rate (Mbps)	2432 kbps max; refer to shipping test data
10	Digital Modulation Type	16/32/64/128 QAM, refer to shipping test data
11	Transmitter Manufacturer	Moseley Associates, Inc.
12	Transmitter Model	SL9003Q
13	Automatic Tx Power Control	No